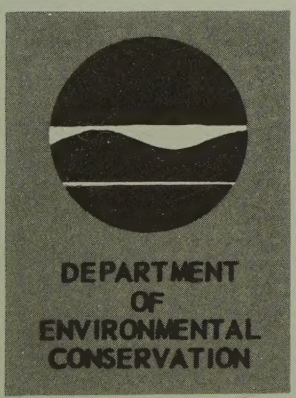
LIBRARY

JUN 7 1982

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

New York Fish and Game Journal



January 1982

STATE OF NEW YORK

Hugh L. Carey, *Governor*

Department ot Environmental Conservation

Robert F. Flacke, *Commissioner*

M. Peter Lanahan, Jr., *First Deputy Commissioner*

Division of Fish and Wildlife

Kenneth F. Wich, *Director*

Robert W. Darrow, *Editor*

NEW YORK FISH AND GAME JOURNAL

VOLUME 29 JANUARY, 1982 NUMBER 1

THE ECOLOGICAL ZONES OF NORTHERN NEW YORK

Gary B. Will Senior Wildlife Biologist

Randall D. Stumvoll Senior Wildlife Biologist

Robert F. Gotie Senior Wildlife Biologist

Edward S. Smith Senior Wildlife Biologist

New York State Department of Environmental Conservation[1]

ABSTRACT

The 14 counties of northern New York are divided into 25 ecological zones on the basis of differences in natural factors and social factors. The criteria used are discussed, and each zone is described.

There exists today, more than ever before, a general awareness that wildlife populations should be managed on an ecosystem basis. Davis (1977) suggested that such a management rationale not only provides the most logical foundation for setting resource policy, but more importantly provides the wildlife manager with a stronger basis for making realistic decisions regarding specific management problems. The applicability of ecological delineation was aptly expressed by Smith (1954): "Knowledge of the primeval conditions on the range and the changes brought about by man's activities helps considerably in predicting the changes that may be expected as the pattern of land use becomes better adjusted to the actual capabilities of the land itself." For the most part, wildlife distribution is controlled by natural factors in the environment. Therefore, the management of a species should be tailored to natural "boundaries". That these boundaries can be recognized by the general public facilitates an understanding of management programs. Ecological zoning is the first step in implementing such an approach.

Describing fundamental differences in the environment and managing wildlife accordingly is not a new concept. The work of Merriam (1894, 1898), Miller (1899), Eaton (1910), Bray (1915), Dice (1943) and others

---

[1]The authors are located at regional headquarters of the Department as follows: Will—Ray Brook, N.Y. 12977; Stumvoll—Warrensburg, N.Y. 12885; Gotie—Cortland, N.Y. 13045; Smith—Watertown, N.Y. 13601.

are classic examples of man's efforts to correlate the limiting effects of such differences (e.g., climate, physiography, etc.) with the distribution of plants and animals in North America. Smith (1955) used data on geology, topography, physiography, climate, soils, water areas, vegetation and land use to derive 11 game ranges in New York.

A major use of ecological zones in wildlife management in New York has pertained to the white-tailed deer (*Odocoileus virginianus*). Morton and Cheatum (1946) divided the State into two regions, and Cheatum and Severinghaus (1950) described five zones based on differences in deer fertility. Later, McCaffrey (1966), using data on age and sex ratios of deer in relation to Smith's game ranges, described 10 deer sections from which the deer management units now used were derived. Further study of the natural factors and social factors involved has led to the recognition of a greater number of zones. The present paper describes those in the 14 counties of northern New York (Figure 1), an area of about 18,000 square miles.

Figure 1. Northern New York as considered in defining ecological zones.

PROCEDURE

Zones were distinguished on the basis of differences in both natural factors and social factors. To assure consistency in identifying differences, the same sources of data were used for each factor. With respect to geology, vegetation and climate, all the information (except as noted) was derived from the work of Stout (1958). This source was used almost exclusively for these features because it provided information on practically all of the criteria considered and because using a single source lessened variation in interpretation.

In delineating the zones, data for each of the several factors were compiled for the region as a whole, and lines designating differences were drawn on map overlays[2]. By superimposing these overlays on one another, similarities in pattern became evident, and lines of demarcation representing the best evaluation were drawn on a base map. These formed the boundaries of the ecological zones recognized. No data on wildlife distribution were used in defining the zone lines.

NATURAL FACTORS CONSIDERED

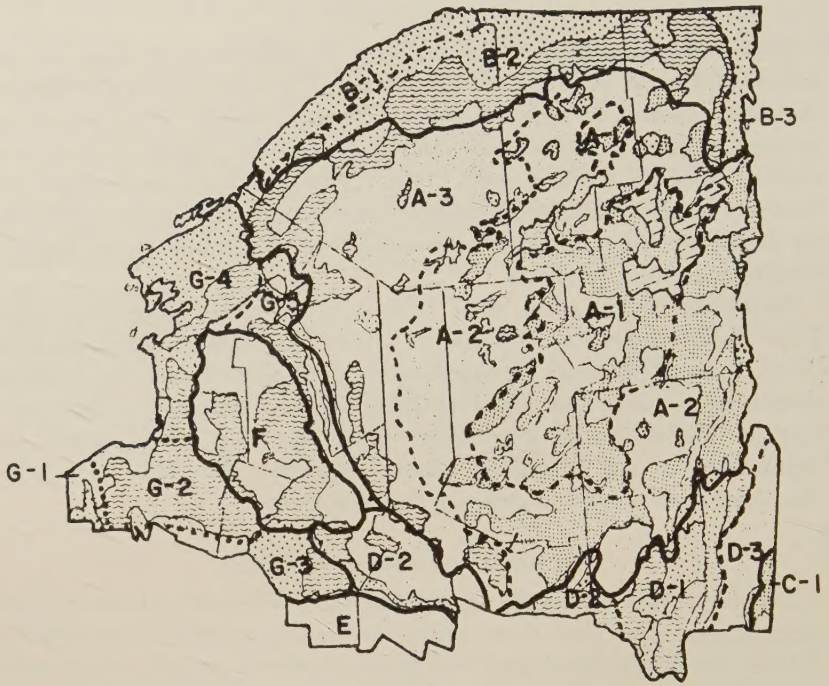
For purposes of this study, natural factors were defined as features of the environment other than those arising from man's activities. The ones considered were: land form and topography, bedrock geology, soil productivity, climate and forest type. All of these have a fundamental influence on the occurrence, distribution and abundance of wildlife.

Land form and topography is a major factor influencing ecological differences. Elevation, slope, drainage and other relief characteristics play a primary role in determining floral and faunal communities and subsequent human activity. The location and extent of these features in northern New York are shown in Figure 2.

Bedrock geology was considered because of its role in determining drainage patterns, soil types, soil productivity and vegetation types. Data given by Merril (1895) were used for denoting differences in the nature and extent of underlying rock formations.

As here considered, soil productivity refers to the basic nature of the soil apart from any modification by man. The productivity of the soil to a large degree determines the quantity, quality and diversity of vegetation in a particular area. It also has a great effect on land use. Since vegetation and land use strongly influence the distribution and abundance of wildlife populations, differences in soil productivity are an important element in delineating ecological zones. The location and extent of areas of high, medium and low productivity in northern New York, based on the work of

[2]These overlays were derived from the Transportation/Planning Map, New York State-North (planimetric series, 1:250,000 scale) published by the New York State Department of Transportation (1974).



A Adirondack Highlands
- A-1 Adirondack Mountain Peaks
- A-2 Adirondack Low Mountains
- A-3 Western Adirondack Hills

B St. Lawrence-Champlain Lowlands
- B-1 St. Lawrence Marine Plain
- B-2 St. Lawrence Hills
- B-3 Champlain Lake Plain

C New England Uplands
- C-1 Taconic Mountains

D Hudson-Mohawk Lowlands
- D-1 Hudson Valley
- D-2 Mohawk Valley
- D-3 Taconic Foothills

E Susquehanna Hills

F Tug Hill Upland

G Erie-Ontario Lowlands
- G-1 Ontario Drumlins
- G-2 Ontario Ridge and Swampland
- G-3 Oneida Lake Plain
- G-4 Eastern Ontario Hills
- G-5 Black River Valley

Flat Plains—Slopes mainly less than 2 per cent; no local relief features

Rolling Hills—Gentle slopes most frequently ranging between 2 and 9 per cent; low local relief marked by elevation changes in tens of feet

Hills—Moderate slopes generally ranging between 9 and 18 per cent; medium local relief marked by elevation changes in hundreds of feet

Rounded Mountains—Steep slopes usually ranging between 18 and 37 per cent; high local relief marked by elevation changes of 1,000 feet

Rugged Mountains—Very steep slopes averaging more than 37 per cent; very high local relief marked by elevation changes in excess of 2,000 feet

Figure 2. Land forms and topography of northern New York; adapted with permission from the Atlas of Forestry in New York by Neil J. Stout (1958).

Stout (1958), are shown in Figure 3. Data given by Cline (1963) were also used in describing the soil associations in the zones recognized.

Climate affects both the habitat of wildlife and the animals themselves.

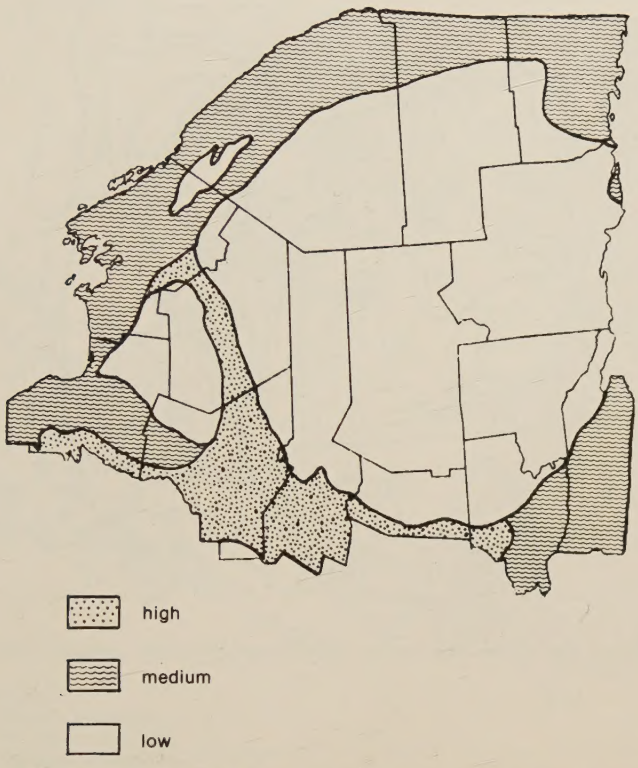


Figure 3. Distribution of soils of different productivity for forest growth in northern New York; adapted with permission from the Atlas of Forestry in New York by Neil J. Stout (1958).

The criteria used were the mean annual snowfall (Figure 4) because of the influence of winter on many wildlife species and the length of the growing season (Figure 5) because of its effect on land use and vegetational composition.

The climax forest type characteristic of an area reflects the combined effects of land form and topography, geology, soil and climate. Also, forest types not only exert a strong influence on the nature of the wildlife populations that occupy them, but by the same token they may be used as an index to the species to be expected in an area. The distribution of the types present in northern New York is shown in Figure 6 according to physiographic region.

SOCIAL FACTORS CONSIDERED

The natural environment in northern New York and its associated wildlife have been affected by man's activities for over 250 years. The social factors considered in this study were land ownership, land use, road

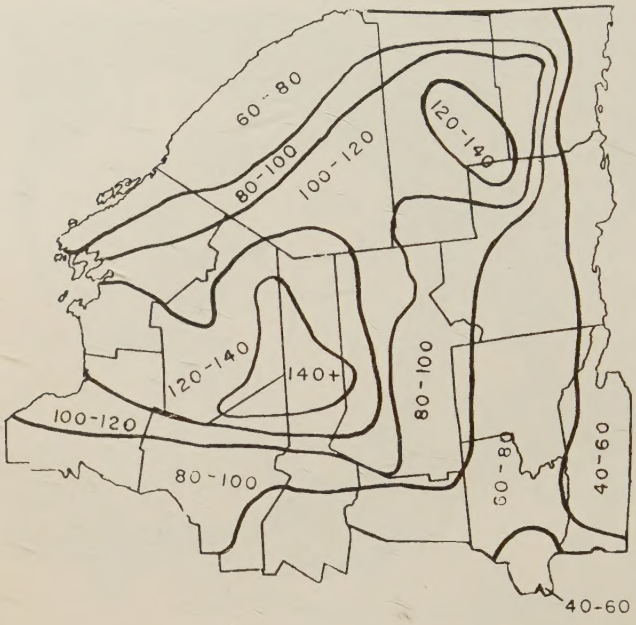


Figure 4. Mean annual snowfall (inches) in northern New York; adapted from Mordoff (1949).

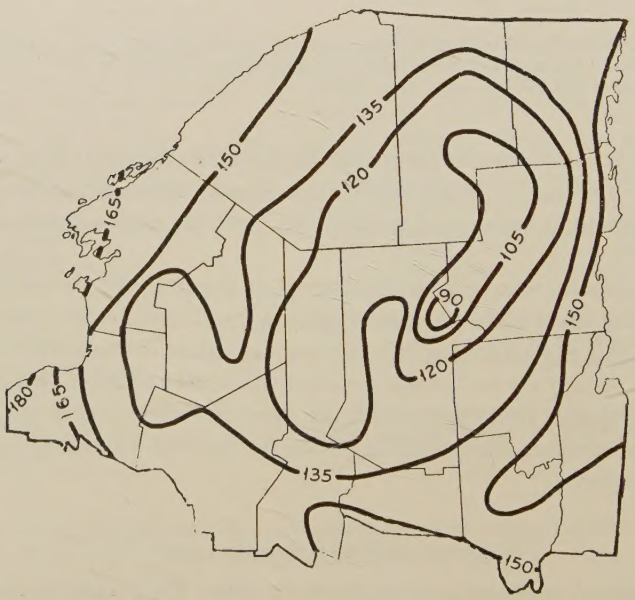
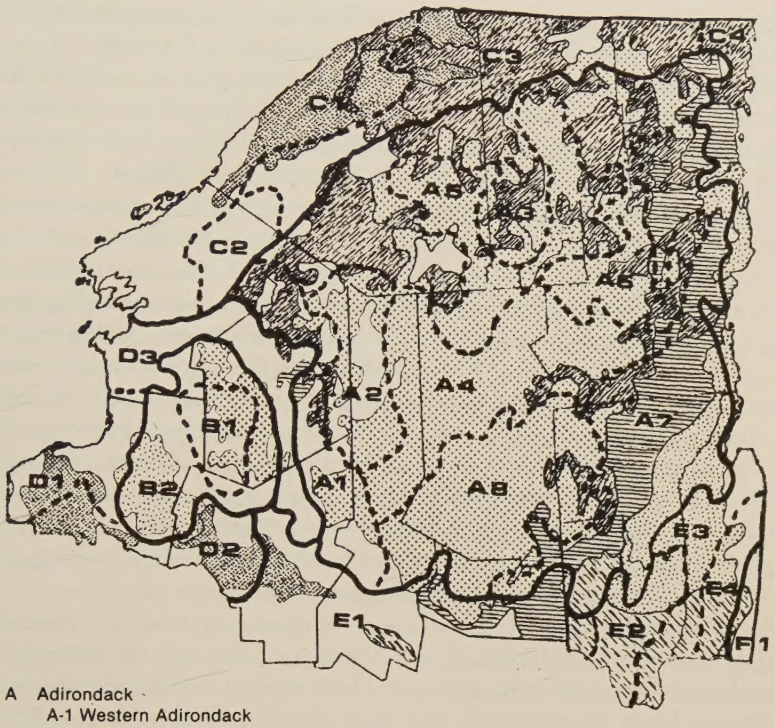


Figure 5. Length of growing season (days) in northern New York; adapted with permission from the Atlas of Forestry in New York by Neil J. Stout (1958).



A Adirondack
- A-1 Western Adirondack
- A-2 Adirondack Foothills
- A-3 Northern Adirondack
- A-4 Central Spruce-Fir
- A-5 Lake and Low Mountain
- A-6 Adirondack High Peak
- A-7 Adirondack White Pine
- A-8 Southern Adirondack

B Tug Hill
- B-1 Central Tug Hill
- B-2 Tug Hill Fringe

C St. Lawrence-Champlain
- C-1 St. Lawrence Plain
- C-2 Rossie Hills
- C-3 St. Lawrence Hills
- C-4 Champlain

D Lake Plain
- D-1 Eastern Ontario
- D-2 Oneida Plain
- D-3 Black River

E Mohawk-Hudson
- E-1 Mohawk
- E-2 Mohawk-Hudson Sands
- E-3 Mid-Hudson
- E-4 Taconic Foothills

F New England Highlands
- F-1 Taconic Highlands

- northern hardwoods
- aspen-gray birch-paper birch
- spruce-fir and northern hardwoods
- white pine and northern hardwoods
- elm-red maple and northern hardwoods
- hemlock-northern hardwoods
- oak-northern hardwoods

Figure 6. Forestry regions and distribution of forest types in northern New York; adapted with permission from the Atlas of Forestry in New York by Neil J. Stout (1958).

access and human population density. Data on these were used to refine preliminary delineations of ecological zones based on the natural factors.

With respect to land ownership, a substantial part of northern New York constitutes the Adirondack Park where roughly 40 per cent of the area is State land and 60 per cent is private land. All State lands within the Park (i.e., the Forest Preserve) are by law to be kept "forever wild", and any timber cutting or other alteration on them except what occurs naturally is prohibited. As a result, distinct differences in wildlife habitat have developed between the State lands and private lands. Outside the Park, the State also owns large acreages of land. Most of this represented abandoned farms when purchased during the Federal resettlement era, and much of it has since been reforested. Although there are more restrictions on these parcels than on private land, State lands outside the Park may be managed for timber products. For this reason, the land ownership pattern was considered in designating some zones. The distribution of State vs. private lands throughout northern New York is shown in Figure 7, based on the Adirondack Park Land Use and Development Plan Map (1972) published by the Adirondack Park Agency and on county recreation maps prepared by the State Department of Environmental Conservation.

Features used as criteria of land use were agriculture, forest, brushland, wetland and other (including cities, industry, roads, etc.) Areas being actively farmed were differentiated from those where land abandonment was prevalent. Land development, and land abandonment, were closely correlated with topographic and soil characteristics. Land use patterns were

Figure 7. Distribution of State lands (dark area) in northern New York; heavy line represents Adirondack Park boundary.

verified by both road and aerial reconnaissance. Aerial photographs[3] were also used as an aid in defining zone boundaries. The Land Use and Natural Resources (LUNR) Inventory[4] was used for data on the acreages involved in each case.

Access is man's way onto the land whether for settlement, use of forest products, clearing for agriculture or recreation. All these activities affect the existence of wildlife. The higher the degree of access, the more interactions between wildlife and man. In addition, the distribution of roads, especially town roads, reflects to a large extent patterns of past use and the limiting effects natural barriers had on early human settlement. For this reason, road access was considered in refining the boundaries of some zones. For the purpose of this study, access was defined as acres served per mile of public road and was estimated according to town (township). Road mileage was determined for town, county and state roads from the Local Highway Systems Inventory: 1973 Town and County Road Mileage published by the State Department of Transportation.

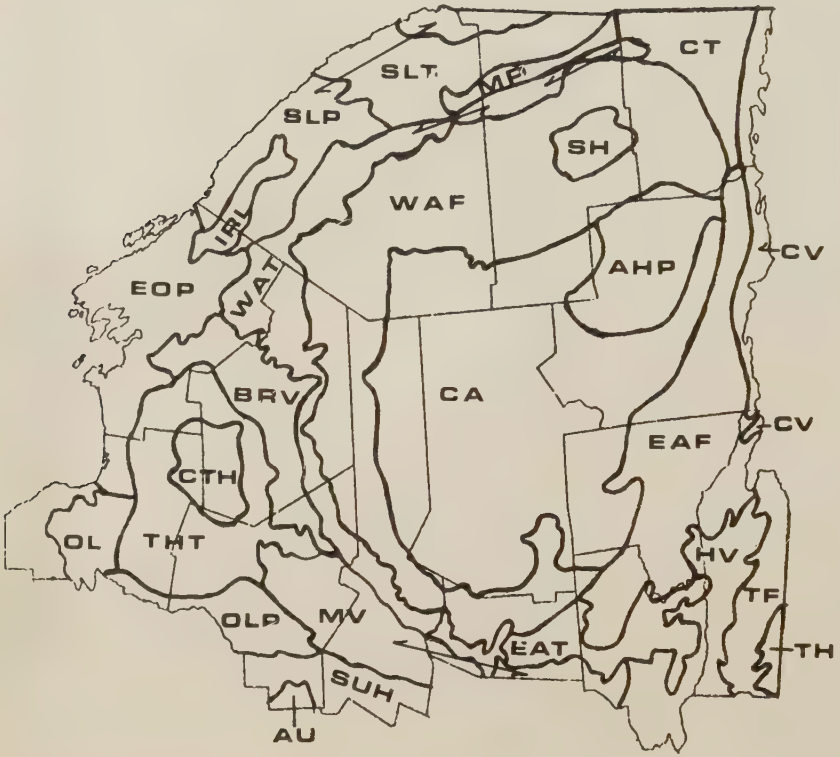
The density of the human population in an area is a primary factory affecting the degree of interaction between man and wildlife. For some species, frequent contact with man may not affect their welfare, but for others it may be detrimental. Therefore, data for the number of people per square mile according to town were also used in refining zone boundaries. Census figures were obtained from the State Board of Equalization and Assessment (1970).

ZONES RECOGNIZED

The 25 zones recognized are shown in Figure 8. Following final delineation of their boundaries, a description of each was prepared. Since most boundaries were closely correlated with differences in the natural factors, the data compiled for those factors could, in the main, be used directly to describe the natural characteristics of the zones. However, data for the social factors were largely in terms of political subdivisions (e.g., towns) that seldom coincide with natural features. Many towns included more than one zone. To minimize bias, data compiled on a town basis were used to describe a zone only when 75 per cent or more of the total land area of the town fell within the zone. This was an arbitrary proportion, but it was felt that it allowed sufficient data to be used for most zones without unreasonable bias. The towns qualifying for inclusion in each zone on this basis are listed in Table 1. Although each zone is distinct, there are

[3]Air photo coverage of Fulton, Warren and Washington Counties in 1968 (scale: 4 inches = 1 mile) obtained from American Air Surveys, Pittsburgh, Penna.

[4]Data compiled by the Department of Natural Resources at Cornell University for the Office of Planning Coordination of the State Department of Commerce.



AHP	Adirondack High Peaks	MV	Mohawk Valley
AU	Appalachian Upland	OLP	Oneida Lake Plain
BRV	Black River Valley	OL	Oswego Lowland
CA	Central Adirondacks	SH	Sable Highlands
CTH	Central Tug Hill	SLP	St. Lawrence Plain
CT	Champlain Transition	SLT	St. Lawrence Transition
CV	Champlain Valley	SUH	Susquehanna Hills
EAF	Eastern Adirondack Foothills	TF	Taconic Foothills
EAT	Eastern Adirondack Transition	TH	Taconic Highlands
EOP	Eastern Ontario Plain	THT	Tug Hill Transition
HV	Hudson Valley	WAF	Western Adirondack Foothills
IRL	Indian River Lakes	WAT	Western Adirondack Transition
MP	Malone Plain		

Figure 8. Ecological zones of northern New York as defined in this paper.

similarities that favor grouping them in four categories: agrarian, transition, forest and non-typical.

Agrarian Category

This category includes 10 zones and encompasses some 4,926 square miles. Their characteristics are summarized and compared in Table 2.

TABLE 1. TOWNS CONSIDERED IN DESCRIBING THE CHARACTERISTICS OF THE ECOLOGICAL ZONES OF NORTHERN NEW YORK*

Zone	Abbreviation	Towns
Agrarian category		
Black River Valley	BRV	Champion, Denmark, Leyden, Lowville, New Bremen, Rutland, Turin and Watertown
Champlain Valley	CV	Essex and Willsboro
Eastern Ontario Plain	EOP	Adams, Alexandria, Brownville, Cape Vincent, Clayton, Ellisburg, Henderson, Hounsfield, LeRay, Lyme, Orleans, Pamelia, Philadelphia, and Sandy Creek
Hudson Valley	HV	Ballston, Clifton Park, Fort Edward, Halfmoon, Kingsbury, Saratoga, Stillwater and Waterford
Malone Plain	MP	Bangor and Lawrence
Mohawk Valley	MV	Charlton, Deerfield, Fairfield, Floyd, Herkimer, Manheim, Marcy, Newport, Perth, Schuyler and Trenton
Oneida Lake Plain	OLP	Rome City, Vernon, Verona and Westmoreland
Oswego Lowland	OL	Hastings, Mexico, Palermo, Schroeppel and Volney
St. Lawrence Plain	SLP	Bombay, Canton, Dekalb, Fort Covington, Gouverneur, Lisbon, Massena, Morristown, Oswegatchie, Potsdam and Waddington
Susquehanna Hills	SUH	Augusta, Columbia, Frankfort, German Flats, Litchfield, Marshall, Paris, Stark, Warren and Winfield
Transition category		
Appalachian Upland	AU	Bridgewater and Sangerfield
Champlain Transition	CT	Altona, Clinton and Mooers
Eastern Adirondack Transition	EAT	Broadalbin, Greefield, Johnstown, Northampton and Wilton
St. Lawrence Transition	SLT	Brasher, Constable, Louisville, Norfolk and Stockholm
Tug Hill Transition	THT	Amboy, Annsville, Ava, Boylston, Camden, Constantia, Florence, Lee, Lorraine, Orwell, Pickney, Vienna, West Monroe, Williamstown and Worth
Western Adirondack Transition	WAT	Croghan, Diana, Dickinson, Hermon, Norway, Parishville, Pierrepont, Remsen, Russell, Russia and Wilna
Forest category		
Adirondack High Peaks	AHP	Jay, Keene, North Elba, St. Armand and Wilmington
Central Adirondacks	CA	Arietta, Benson, Harrietstown, Indian Lake, Inlet, Johnsburg, Lake Pleasant, Long Lake, Minerva, Morehouse, Newcomb, Stony Creek, Thurman, Webb and Wells

TABLE 1. *(continued)*

Zone	Abbrev-iation	Towns
Central Tug Hill	CTH	Lewis, Osceola and West Turin
Eastern Adirondack Foothills	EAF	Bolton, Chester, Chesterfield, Crown Point, Dresden, Edinburg, Hadley, Hague, Horicon, Lake George, Lake Luzerne, Lewis, Moriah, Ticonderoga and Warrensburg
Sable Highlands	SH	None
Western Adirondack Foothills	WAF	Bellmont, Black Brook, Bleecker, Brighton, Caroga, Clare, Colton, Danemora, Edwards, Fine, Greig, Hope, Hopkinton, Pitcairn, Salisbury, Santa Clara, Saranac, Stratford and Waverly
Non-typical category		
Indian River Lakes	IRL	Macomb and Rossie
Taconic Foothills	TF	Cambridge, Granville, Greewich, Hampton, Hebron, Jackson and Salem
Taconic Highlands	TH	White Creek

*Towns considered are those where 75 per cent or more of the land area is within zone.

The bedrock in these zones contains various limestone and sandstones. The topography is generally flat to rolling plains with elevations usually less than 500 feet above sea level. Areas with well drained soils tend to be highly productive agriculturally, while those that retain spring runoff exhibit a medium productivity. Because of their low elevation and general proximity to water, these zones have the longest growing seasons and lowest annual snowfall in northern New York, although there are exceptions especially at higher elevations. Forest areas consist of sparse northern hardwoods, white pine and oak in a typical small woodlot pattern.

The natural features of the agrarian zones are favorable for intensive human use, one reason why most of the land is in private ownership. The productive soils and temperate climate are conducive to dairy and fruit farming. Many farm incomes are supplemented by the sale of forest products such as lumber, fence posts and maple syrup. Expansion of urban areas and development of light industry account for an increasing human population. This human activity is further reflected by the extensive road network that makes these zones highly accessible.

Agriculture should continue to flourish on the more productive lands in the agrarian zones, but expansion is doubtful because of demands of urban areas and the inadaptability of the poorer and smaller sites to modern agricultural technology. Land abandonment on the fringes of these zones will continue and thereby increase the extent of the transitional zone.

BLACK RIVER VALLEY The Black River Valley occupies about 350 square miles. It has an average elevation of 1,000 feet and is characterized by rich Ontario loam soils underlain by Trenton limestones. Because of its

location in relation to the higher Tug Hill plateau to the west, it has an annual snowfall of 100 to 140 + inches. The growing season approaches 150 days. Woodlots, chiefly northern hardwoods, are widespread.

The most unusual feature of this zone is its existence as an agricultural entity squeezed between two large and rather infertile forest regions. It is easily separated from adjoining areas on both the east and west by land-use changes, i.e., intensive agriculture abruptly giving way to abandoned land and secondgrowth oldfield forests. Specifically, these changes coincide on the east with the western edge of the Precambrian Shield and on the west with the eastern escarpment of the Tug Hill plateau. The southern boundary of the Black River Valley is the divide between the Mohawk River and Black River drainages. On the north the boundary follows the northern escarpment of the Tug Hill plateau and the margin of the flat Eastern Ontario Plain.

CHAMPLAIN VALLEY The Champlain Valley encompasses about 288 square miles. The elevation ranges from 100 to 700 feet and averages about 200 feet. The area is characterized by Vergennes clay soils originating from glacial lake sediments underlain by Trenton limestones. Annual snowfall is 40 to 60 inches, and the growing season varies from 135 to 150 + days. The typical natural forest consists of white pine, northern hardwoods and some pioneer species.

The most unique features of this zone include gentle relief and a milder climate than that in most other parts of the region, both of which are favorable for grain and orchard farming. Its proximity to Lake Champlain lengthens the growing season and moderates the annual snowfall. The percentage of forested land as given in Table 2 is biased upward compared with that in other zones because only two towns were considered.

The Champlain Valley is bounded on the east by Lake Champlain and on the west and south by the Precambrian Shield. On the north it extends to the International Boundary.

EASTERN ONTARIO PLAIN The Eastern Ontario Plain occupies about 756 square miles. It is a nearly level area ranging in elevation between 250 and 500 feet with an average of 300 feet. Like the Champlain Valley, the soils are predominantly glacial lake sediments of medium productivity underlain by Trenton limestone. The climate is moderately favorable for agriculture with a growing season of 150 to 165 days and an annual snowfall of 60 to 80 inches. Due to the climatological effects of Lake Ontario, this zone is quite favorable to dairy farming which has established it as the leading producer of dairy products in the Northeast. Lake Ontario and the St. Lawrence River bound the zone on the west and north. On the east and south, the boundary represents no well defined natural or sociological feature but rather reflects subtle changes in topography and the intensity of agriculture due to differences in bedrock geology, soil productivity and climate.

TABLE 2. COMPARATIVE CHARACTERISTICS OF THE ECOLOGICAL ZONES OF NORTHERN NEW YORK

Zone*	Natural factors					Social factors								
								Land use (per cent)						
	Area (square miles)	Elevation (feet)	Soil productivity§	Annual snowfall (inches)	Growing season (days)	Basic economy†	Land ownership (per cent and type§§)	Agriculture	Forest	Brush	Wetland	Other††	Human population density‡	Access‡‡
Agrarian category														
BRV	350	800-1,400	H	100-140	135-150	D	100 P	54.7	15.9	17.1	3.7	8.6	39	369
CV	288	100- 700	L-M	40- 60	135-150	A	100 P	34.0	31.4	18.7	7.3	8.6	60	367
EOP	756	250- 500	M	60- 80	150-165	D	99 P	39.1	8.6	13.6	4.6	34.1	30	404
HV	570	200- 500	M-H	40- 60	145-165	D,S	100 P	32.8	22.0	19.5	4.4	21.3	334	253
MP	175	400-1,000	M	100-120	120-150	A,D,R	100 P	36.1	16.6	38.2	1.4	7.7	40	379
MV	920	500-1,200	H	80-100	135-150	D,I	95 P	45.6	19.4	21.4	1.0	12.6	81	318
OLP	308	300- 600	H	80-100	135-150	D,I	100 P	40.7	10.7	20.4	8.5	19.7	96	289
OL	304	300- 500	M	80-120	135-150	I,d,O	100 P	28.5	5.7	32.6	14.8	18.4	84	309
SLP	858	250- 400	M	60-100	150-165	D,R,I	99 P	34.4	13.8	28.0	9.3	14.5	34	416
SUH	397	500-1,200	H	60- 80	135-150	D	100 P	50.0	17.7	21.0	3.0	8.3	56	268
Transition category														
AU	64	1,500-1,800	L	60- 80	150	d,I	75 P	33.3	16.5	37.4	5.7	7.1	29	298
CT	268	300-1,200	M	40-100	135-150	R,F,H	90 P	23.6	34.8	29.0	9.1	3.5	20	472
EAT	342	300-2,000	L-M	60- 80	140-150	W,S	85 P	12.0	54.2	18.6	4.9	10.3	92	312
SLT	463	300-1,000	M	60-100	135-150	R,a	80 P	16.6	40.5	24.4	8.0	10.5	37	415
THT	1,113	1,000-1,700	L	120-140	135-140	R,d,L	75 P	14.2	37.7	24.8	11.8	11.5	33	430
WAT	1,237	800-1,500	L	100-140	120-135	R,L,d	80 P	10.2	52.1	21.9	8.1	7.7	19	546

Forest category														
AHP	785	1,000-5,344	L	60-140	90-135	R	90 FP	0.3	90.2	2.6	2.7	4.2	12	2,236
CA	3,198	1,300-4,000	L	80-140	90-150	R	75 FP	0.0	89.9	2.1	6.6	1.4	8	2,427
CTH	299	1,500-1,900	L	120-140	135	R,L	100 P	6.6	67.5	11.5	12.9	1.5	4	1,009
EAF	1,538	500-3,000	L	60- 80	125-150	F,R	70 P	2.4	82.9	7.3	2.3	5.1	40	786
SH	227	1,300-3,400	L	100-140	105-120	R,F	50 P	#	#	#	#	#	#	#
WAF	3,392	1,200-2,000	L	120-140	105-135	R,L	50 P	2.0	77.4	8.8	10.0	1.8	17	1,043
Non-typical category														
IRL	241	350- 500	L	60-100	150-165	R,I,d	98 P	35.8	16.1	26.6	8.8	12.7	15	431
TF	411	400-1,200	M	40- 60	145-165	D	100 P	34.1	33.5	19.2	3.7	9.5	50	335
TH	38	500-1,800	M	40- 60	140	R,a	85 P	25.2	39.0	26.1	0.7	9.0	54	421

* Abbreviations as given in Table 1.

§ Symbols: H = high; M = medium; L = low.

† Symbols: A = general agriculture; a = limited general agriculture; D = intensive dairying; d = low-key dairying; F = forest operations (other than logging); H = hay; I = local industry - manufacturing (may include wood products); L = logging; O = orchards; R = recreation; S = residential; W = wood products industry.

§§ Symbols: P = private; FP = Forest Preserve.

†† Includes residential, commercial-industrial, transportation, outdoor recreation areas, etc.

‡ Number per square mile.

‡‡ Acres served per mile of road (state, county and town).

No data because zone did not include 75 per cent of any one town.

Hudson Valley The Hudson Valley as considered here occupies 570 square miles and is contiguous with a similar zone that extends southward to the mouth of the Hudson River. The elevation ranges between 200 and 500 feet with an average of 300 feet. Derived from underlying Hudson River shale and lucustrine-aeolian glacial deposits, the soils are high to medium in productivity. Being relatively flat with good access by both land and water, this area has been intensively developed by man and supports an average population of 334 people per square mile.

All the land in this zone is privately owned with farming being the major industry. The growing season approaches 165 days and the annual snowfall rarely exceeds 60 inches. Forested lands that do exist are found on less suitable sites or surrounding housing developments. The major components are mixtures of oaks, northern hardwoods and white pine. The uniqueness of this zone is the density of the human population and its effect on land use; it is the most heavily populated in northern New York.

The flat intensively cultivated lands of the Hudson Valley separate it from the more rolling less intensively used lands of adjacent zones to the north, east and west. Although for purposes of this study its southern boundary coincides with the Warren and Washington County lines, it differs from the neighboring Mohawk Valley to the south in climatic and soil characteristics.

Malone Plain The Malone Plain occupies about 175 square miles and ranges in elevation from 400 to 1,000 feet, averaging 600 feet. It is characterized by Vergennes clay soils of medium productivity and a bedrock of Potsdam sandstones. Generally the topography varies from flat to rolling plains. Annual snowfall ranges from 100 to 120 inches, and the growing season is 120 to 150 days. The forest type is aspen, gray birch and paper birch.

The most unique feature of this zone is its gentle relief and the continuing extent of agriculture. Potato and grain farms form a patchwork design. Although agriculture is important, land abandonment is continuing as evidenced by the encroachment of the surrounding transition zones. As the cost of farming and degree of urban development increase, this zone will probably continue to shrink and meld into these transition zones. The chief difference between it and surrounding zones is the continuum of active farmland.

Mohawk Valley The Mohawk Valley comprises some 920 square miles of flat to rolling hills that range in elevation from 500 to 1,200 feet, averaging 1,000 feet. The bedrock consists of a conglomeration of Hudson River shale, Clinton and Medina sandstones and Clinton limestone overlain by highly productive soils of the Ontario, Cassayuna and Chenango groups. The annual snowfall is 80 to 100 inches, and the growing season approaches 150 days. Situated along a major commerce route with good access, this historic region supports a manufacturing industry and inten-

sive dairy farming. Its forests are predominantly northern hardwoods. The zone is bounded on the north by the southern margin of the Precambrian Shield and the divide between the Black River and Mohawk River drainages. It may be distinguished from adjoining zones to the south by differences in bedrock geology, as well as its lower annual snowfall and the greater density of its human population.

ONEIDA LAKE PLAIN The Oneida Lake Plain occupies about 308 square miles primarily characterized by flat plains with an elevation ranging from 300 to 600 feet and averaging 500 feet. The bedrock is sedimentary consisting of Clinton sandstone and limestone. The soils belong to the Junius-Granby association and are of high productivity. The growing season approaches 150 days, and the annual snowfall reaches 100 inches. Because of these physical features and the moderating influence of Oneida Lake, dairy farming is widespread. Good public access and a high human population tend to make the area favorable for manufacturing. Forest cover is closely linked to the swamp types of elm and red maple. Northern hardwoods are typically found on the higher sites in a small-woodlot distribution.

The boundary of this zone is best defined by the extent of the flat plains of the Oneida Lake basin which formed the eastern terminus of ancient Lake Iroquois. However, the major part of this basin lies in Madison and Onondaga Counties outside northern New York as considered here.

OSWEGO LOWLAND The Oswego Lowland consists of some 304 square miles of rolling plains ranging in elevation from 300 to 500 feet. The bedrock is composed of Clinton and Medina sandstones. The soils are generally medium in productivity and largely belong to the Worth and Salina muck soil association. Average annual snowfall approaches 120 inches, and the growing season reaches 150 days. The warming effect of Lake Ontario and the physical features of the land favor an agrarian economy, e.g., low-key dairy farming, orchards and muck farms. Good access and proximity to an urban population have facilitated the establishment of a manufacturing industry.

The Oswego Lowland is bordered on the east by the Tug Hill Transition Zone where the elm-red maple forest type associated with numerous wetland soils gives way to the upland northern hardwoods type. The change is gradual due to the gentle increase in elevation and subtle differences in bedrock geology and soil productivity as well as in the intensity of land use. On the west, part of its boundary with the Eastern Ontario Plain is an area marked by numerous glacial features of the drumlin, kettle and kame class. Its southern boundary as considered here is mainly political, the Oswego County line, but the zone ultimately adjoins the Oneida Lake Plain where snowfall is less and urban development greater.

ST. LAWRENCE PLAIN The St. Lawrence Plain occupies about 858 square miles and in general comprises flat and rolling plains ranging in

elevation from 250 to 400 feet and averaging 300 feet. The bedrock consists of Trenton limestone and Potsdam sandstone. The soils are of medium productivity and belong to the Granville-Swanton-Livingston-Grenville series. Annual snowfall is 60 to 100 inches, and the growing season is 150 to 165 days. Northern hardwoods are the dominant forest type and are found in small woodlots usually located in low-lying swampy areas. A large proportion of brushland exists as a result of land abandonment.

Higher agricultural use distinguishes the St. Lawrence Plain from the transition zones to the north and east. It is also distinguished from the still more agriculturally productive Eastern Ontario Plain to the south by the presence of more hills and swamp forest timber (elm, red maple, etc.). The St. Lawrence River forms the western boundary.

Susquehanna Hills The Susquehanna Hills comprise some 397 square miles of rolling hills with an elevation of 500 to 1,200 feet. The bedrock consists of limestones of the Lower and Upper Helderberg series. The soils belong to the Cazenovia-Honeoye associations and are of high productivity. The growing season approaches 150 days. The forest association is typically northern hardwoods. Like the other agrarian zones in northern New York, access and population density reflect a high degree of human activity. Lower annual snowfall and a difference in the underlying bedrock distinguish this zone from the Mohawk Valley to the north. The divide between the Mohawk River and Susquehanna River drainages defines its southern boundary. To both the east and west it continues outside the northern New York region.

Transition Category

This category represents the ecotone between cleared lands and forest. In northern New York it includes six zones and encompasses some 3,487 square miles. Their characteristics are summarized and compared in Table 2. Precambrian bedrock, shale and sandstone form the basic geology of these zones. The typical land form is gently rolling plains and low hills that range in elevation from 300 to 1,800 feet above sea level with an average of 1,000 feet. Rocky outcroppings and poorly drained areas, as well as soils of mostly low productivity, characterize the region. The growing season is similar to that in the agrarian zones, except that higher elevations and the lack of a warming effect from large bodies of water limit the expected number of frost-free days. Annual snowfall is usually greater and accumulations persist longer. White pine, oak and northern hardwoods are the predominant forest types.

As a group, the various transition zones have a similar history of land use. Small, self-sustaining homesteads were prevalent in the early 1900's and accounted for almost 80 per cent of all land use. Those farms with poorer soils and rocky outcroppings could not be adapted to mechanized

and scientific agriculture and were slowly abandoned. This phenomenon started during the late 1800's, rapidly accelerated in the 1930's and continues today at a slower rate. Abandoned pasture and crop lands allowed regeneration of pioneer plant, shrub and tree species. Stands of second-growth timber still exist on most of the lands abandoned during the early years. Some 80 to 90 per cent of the land is in private ownership and is used largely as a source of wood products such as pulp and firewood. In addition, these zones are "suburbia" for neighboring industrial communities and also provide recreational second-home sites. An interesting characteristic of this region is the prevalence of fences overgrown with vegetation. Although changes in land use and vegetation have taken place, access and human population density continue to be quite high. It is anticipated that the boundaries of the transition zones will fluctuate as more marginal farms are abandoned and forest types develop and mature. Nevertheless, collectively they may be distinguished as an area characterized by abandoned farmland and lying between the forest and actively cultivated agricultural lands.

APPALACHIAN UPLAND The Appalachian Upland occupies only about 64 square miles in northern New York, but it is the northernmost extension of a much larger zone to the south, i.e., the Appalachian Plateau. Topographically, it consists of rolling hills ranging in elevation from 1,500 to 1,800 feet and averaging 1,600 feet. The bedrock of Hamilton shale is overlain by low-productivity soils of the Lordstown-Marden-Volusia association. Despite mild climatic conditions, the topographic features and poor soils have caused much land retirement. Secondgrowth timber composed primarily of northern hardwoods or plantations of red pine have taken over abandoned fields. To the north this zone adjoins the Susquehanna Hills where slopes are more gentle and agriculture more intensive.

CHAMPLAIN TRANSITION The Champlain Transition occupies about 268 square miles and consists of flat and rolling plains varying from 300 to 1,200 feet in elevation and averaging 700 feet. Fairly well drained Potsdam sandstones overlain by Vergennes clay with a moderate lime content have resulted in soils of medium productivity. Annual snowfall varies from 40 to 100 inches. Forest types are chiefly aspen, gray birch, paper birch and northern hardwoods with some white pine, red spruce and balsam fir. Compared with the other transition zones, the lower elevation and gentle topography, better soil productivity and a longer growing season have, together, made this zone more attractive for agriculture.

In New York, the Champlain Transition extends to the International Boundary. Its high degree of agricultural land use distinguishes it from zones to the west and south where secondgrowth on formerly cleared and cultivated lands is widespread. To the east, the Champlain Valley is flatter and has a milder climate.

EASTERN ADIRONDACK TRANSITION The Eastern Adirondack Transition occupies about 342 square miles and consists mostly of rolling

plains with elevations ranging from 300 to 2,000 feet and averaging 700 feet. The bedrock is a mixture of Precambrian granites, Potsdam sandstones, Trenton limestones and acid glacial till. The soils belong to the Broadalbin-Mosherville association and are medium to low in productivity. Two features distinguish this zone from the other transition zones. First, although all of them contain secondgrowth forest, the Eastern Adirondack Transition has a significant proportion of oak. Second, its proximity to metropolitan areas has resulted in a higher human population density. Its more gentle slopes and evidence of more intensive land use in the past, including agricultural clearings, separate this zone from the more inaccessible Eastern Adirondack Foothills to the north. The high degree of land abandonment in this zone forms a striking contrast to the intensively farmed lands to the south and east.

St. Lawrence Transition The St. Lawrence Transition encompasses about 463 square miles and ranges in elevation from 300 to 1,000 feet and averages 400 feet. The bedrock consists of Potsdam sandstones. The soils belong to the Colton-Adams-Hinckley and Windsor association and are low to medium in productivity. Annual snowfall is 60 to 100 inches, and the growing season is 135 to 150 days. Until midcentury, agriculture was the principal land use, but low soil productivity has led to the retirement of once active farms. Much of the area is now in State ownership, acquired under the Federal resettlement program. Forest types are predominantly aspen, gray birch and paper birch and along with brushland make up 65 per cent of the vegetative habitat. The zone is largely surrounded by the agriculturally productive St. Lawrence Plain and Malone Plain.

Tug Hill Transition The Tug Hill Transition comprises some 1,113 square miles of low rolling hills ranging in elevation between 1,000 and 1,700 feet. The bedrock is Hudson River shale and is associated with low-productivity soils of the Worth-Empeyville-Westbury series. Although the annual snowfall is comparable to that of the Central Tug Hill, the lower elevation results in a little longer growing season, 135 to 140 days. The forest type is predominantly northern hardwoods, although to the west hemlock becomes a more important species. Marginal dairy farms, the majority of which are located in the southern part of the zone are characteristic of the agriculture. Over the past four decades, much of the farmland has been abandoned resulting in the encroachment of pioneer species and the establishment of softwood plantations, mainly as State reforestation areas. Submarginal farmland and the nature of past land use are probably the most characteristic feature of this zone. It is entirely surrounded by zones of the Agrarian Category where the soils are more fertile and the climate milder. Greater access and higher human population density separate it from the more heavily forested Central Tug Hill.

Western Adirondack Transition The Western Adirondack

Transition encompasses some 1,237 square miles of northern New York. The bedrock is of Precambrian origin and the soils are poor. Annual snowfall is 100 to 140 + inches, and the growing season is less than 135 days. Land use is chiefly a mixture of old fields, secondgrowth forests and "sand farms". The most striking difference between this zone and the other transition zones (except for Tug Hill) is the severity of the climate. Also, its geology is different, its topography more rough, its soils poorer and its agriculture less prosperous.

FOREST CATEGORY

In this category extensive forest is the dominant vegetative feature. In northern New York it includes six zones and encompasses some 9,400 square miles. Their characteristics are summarized and compared in Table 2. The bedrock is primarily composed of Precambrian granites with an occasional mixture of Medina sandstone or gneisses. The topography is generally described as rounded mountains. Soils are of low productivity. Annual snowfall ranges from 60 to 140 + inches. The growing season varies from 90 to 150 days and in the high peak area is the shortest in the State. Forests occupy 67 to 90 per cent of the total land area in these zones and include more than 30 species of deciduous and coniferous trees.

The mountainous terrain, poor soil and severe climate have governed man's use of the land. The primary industries are based on forest products and recreation. Agriculture is practically non-existent, less than 5 per cent of the land being used for this purpose. Unlike the transition zones where brushland areas are largely a result of farmland abandonment, most brushlands here are directly related to logging. Land ownership has played a particularly important role with respect to the use of lands in this category. Poor logging practices, misuse of the land and destruction of watersheds changed public attitudes and, in the late 1800's, resulted in the establishment by amendment to the State Constitution of the Adirondack Park wherein State-owned lands (i.e., the Forest Preserve) are to be "forever wild", i.e., they may not be leased or sold and logging is prohibited. In addition to the State lands existing at that time, considerable acreages have since been acquired, mainly within the Park but also elsewhere in these zones. More recently, legislation was enacted in 1972 to regulate land-use practices on private lands in the Park. These restrictions on land use, together with effective fire control, have perpetuated the forest character of this region.

ADIRONDACK HIGH PEAKS The Adirondack High Peaks zone occupies about 785 square miles and consists of rugged and rounded mountains with elevations ranging from 1,000 to 5,344 feet and averaging 2,500 feet. The climax forest consists of spruce, fir and northern hardwoods. Some 90 per cent of the land is in State ownership as Forest Preserve. The outstanding feature of this zone is its topography which directly influences

the types of habitats present, the most unusual being the alpine biome. The rugged terrain distinguishes it from the foothills and Central Adirondacks, although the Bald Mountain area was included in the Eastern Adirondack Foothills because of the climatic influence of Lake Champlain.

Central Adirondacks The Central Adirondacks zone encompasses some 3,198 square miles and consists of hills and rounded mountains with elevations ranging from 1,300 to 4,000 feet and averaging 2,000 feet. It has an annual snowfall of 80 to 140 inches and a short growing season of 90 to 150 days. The climax forest consists of spruce, fir and northern hardwoods. The chief characteristics of this zone are its topography, vegetation and landownership. More than 75 per cent of the land is State-owned as Forest Preserve. Combined with the elevation and climate, this has determined land use, public access, recreation and human population density. The eastern boundary of this zone represents the separation of the spruce-fir associations of the Central Adirondacks from the white pine associations of the Eastern Adirondack Foothills. Elsewhere, it is distinguished from adjoining zones by differences in topography, climate and vegetation. To the north, land ownership was also a key factor.

Central Tug Hill The Central Tug Hill zone occupies about 299 square miles of flat or rolling terrain with elevations ranging from 1,500 to 1,900 feet and averaging 1,700 feet. Poorly drained soils of the Worth-Empeyville-Westbury association account for the large proportion of wetland area. This plateau represents a substantial barrier over which moisture-laden air from Lake Ontario must pass as cyclonic storm systems move eastward. The result is great accumulations of snow, 120 to 140 + inches annually. Although the growing season is 135 days, summer temperatures are cool. The area is densely forested with cutover northern hardwoods, spruce and fir. Because of a harsh climate and poor soils, the area was never developed for agriculture. On the other hand, the vast amount of forest land coupled with extensive private ownership makes it favorable for logging and outdoor recreation. This zone is distinguished from the Tug Hill Transition by its higher elevation, more difficult public access and lower human population density.

Eastern Adirondack Foothills The Eastern Adirondack Foothills encompass some 1,538 square miles characterized by hills and rounded mountains with elevations ranging from 500 to 3,000 feet and averaging 1,400 feet. Annual snowfall is 60 to 80 inches, and the growing season ranges from 125 to 150 days. Typical forest species include white pine, oak and northern hardwoods, the oak association reaching its northern limit here. These forest types differentiate this zone from the Central Adirondacks where spruce-fir types predominate. It is distinguished from agrarian zones to the east by a lack of agriculture and the abrupt eastern margin of the Precambrian Shield which also marks a change in the typical

vegetation. The greater slope of the Precambrian Shield in this zone and a somewhat milder climate separate it from the Western Adirondack Foothills.

SABLE HIGHLANDS This zone of about 227 square miles is surrounded by the Western Adirondack Foothills. It consists of hills and rounded mountains with elevations varying from 1,300 to 3,400 feet and averaging 2,000 feet. Annual snowfall ranges from 100 to 140 inches, and the growing season varies from 105 to 120 days. The present forest consists of pioneer hardwoods, spruce and fir, their distribution largely dependent on landownership. The proportions of State and private lands are about equal. Rugged mountains not characteristic of the foothills, as well as the absence of wetlands and the extent of forest habitat, distinguish this zone. Topography and poor soils have governed man's use of the land.

WESTERN ADIRONDACK FOOTHILLS The Western Adirondack Foothills occupy some 3,392 square miles and are physically similar to the Central Adirondacks and Eastern Adirondack Foothills, but the topography is much less abrupt with a gradual western slope. The average elevation is 1,500 feet with a range of 1,200 to 2,000 feet. Annual snowfall is 120 to 140 inches and the growing season is less than 135 days, both of which are significantly influenced by the westerly slope and prevailing westerly winds. Forests and brush occupy more than 85 per cent of the area with wetlands typifying the numerous river and stream floodplains. The climax forest type is spruce, fir and northern hardwoods. Man's continued logging activities have created more diversity in forest composition here than in any other forest zone. Lands are mostly in private ownership and comprise large single-owner estates, paper company properties and hunting club tracts. Access is twice that in the Central Adirondacks and High Peaks zones, reflecting greater demand and use of forests for wood products and recreation. Human settlement is relatively low, but the population density is double that in the Central Adirondacks.

NON-TYPICAL CATEGORY

This category encompasses some 690 square miles and includes three zones that, although they exhibit similarities to those in other categories, have unique differences as shown in Table 2.

INDIAN RIVER LAKES The Indian River Lakes occupy about 241 square miles surrounded by the St. Lawrence Plain and Eastern Ontario Plain. It consists of rolling hills 350 to 500 feet in elevation with many granite outcrops. The underlying bedrock is Precambrian granite intruding sedimentary rocks of the Potsdam sandstone series. Its Rockland soils are very shallow, poorly drained and of low productivity. Annual snowfall ranges between 60 and 100 inches, and the growing season is more than 150 days. The moderate climate has produced forest types representing a transition between northern hardwoods and more southerly associations

such as the oak-hickory. It supports a marginal dairy industry and has many glacial lakes that provide high recreational use. The prevalence of rock outcrops, rough terrain and lakes situated in an otherwise flat to rolling plain distinguishes it from the surrounding zones.

Taconic Foothills The Taconic Foothills consist of about 411 square miles and represent the westernmost extension of Vermont's Green Mountains. The topography is basically hills ranging in elevation from 400 to 1,200 feet and averaging 800 feet. The bedrock is Hudson River shale in combination with limestone and Lower Cambrian slate. The soils, which are of medium productivity, belong to the Troy-Cassayuna association and are similar to those of the neighboring Hudson Valley. Annual snowfall ranges from 40 to 60 inches, and the growing season varies from 145 to 165 days. Secondgrowth northern hardwoods with a high mixture of oak and hickory, as well as old fields in various stages of succession, evidence a continuing trend of land abandonment and changing land use. At one time this zone was heavily cultivated, and therefore a good road network still exists, but land abandonment has decreased the human population density. It is probable that land use will follow a pattern similar to that in the transition zones, but at a much slower rate because the more productive soils and less severe climate allow agricultural practices that facilitate better competition with the mechanized farming in the agrarian zones. This zone is distinguished from the Hudson Valley to the west by its more rolling terrain, and from the Taconic Highlands to the east by its more gentle relief and greater agricultural use.

Taconic Highlands The Taconic Highlands constitute a 38-square-mile finger of the Green Mountains of Vermont ranging in elevation from 500 to 1,800 feet and averaging 1,000 feet. The bedrock of Lower Cambrian slate and limestone is overlain by Dutchess-Nassau soils of medium productivity. Annual snowfall varies from 40 to 60 inches, and the growing season averages 140 days. Once heavily cultivated, the land is now dominated by secondgrowth northern hardwoods, oak and hickory and large areas of brush. Although abandonment of unproductive small farms is a continuing trend, the density of the human population has not declined as much as that in the Taconic Foothills, due in part to the purchase of many small farms as rural residences. This zone is distinguished from the foothills to the west by being a contiguous part of the Green Mountains and by its extensive forest cover.

DISCUSSION

It has become increasingly apparent that effective wildlife management must be correlated with existing ecological differences in the range. In redefining the ecological zones of northern New York, the present approach closely resembles those of Smith (1954) and Stout (1958). Their work served well in delineating game range and orienting forest management on

the basis of information available at the time. However, recent advances in technology have greatly enhanced our knowledge of environmental conditions making it possible to predict future land differences more accurately. In addition, the present study went beyond Smith's analysis in giving greater consideration to man as a natural force continually shaping the character of the land and associated fauna and flora. The authors have attempted to develop a more understandable methodology that will enable others to make comparable assessments more easily in the future.

LITERATURE CITED

BRAY, W. R. 1915. The development of the vegetation of New York State. N.Y.S. Coll. Forestry, Tech. Publ. 3.

CHEATUM, E. L., AND C. W. SEVERINGHAUS. 1950. Variations in fertility in white-tailed deer related to range conditions. Trans. N. Am. Wildl. Conf. 15:170-190.

CLINE, M. G. 1963. Soils and soil associations in New York. N.Y.S. Coll. Agric., Coop. Ext. Serv., Bull. 930.

DAVIS, J. A. 1977. An ecosystem classification of New York State for natural resource management. N.Y. Fish and Game Jour. 24(2):129-143.

DICE, L. R. 1943. The Biotic Provinces of North America. Univ. Mich. Press, Ann Arbor, Mich.

EATON, E. H. 1910. Birds of New York—Part 1. New York State Museum, Memoir 12.

MCCAFFREY, E. 1966. Recording the age and sex composition of deer taken during the hunting season. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R (annual report for Job II-A). N.Y.S. Cons. Dept. (mimeo.)

MERRIAM, C. H. 1894. Laws of temperature control of the geographic distribution of terrestrial animals and plants. National Geographic 6:229-238.

_____ 1899. Life zones and crop zones of the United States. U.S. Dept. Agric., Bur. Biol. Survey, Bull. 10.

MERRIL, F. J. 1895. Economic and Geologic Map of New York. New York State Museum.

MILLER, G. S., JR., 1899. Preliminary list of the mammals of New York. New York State Museum Bull. 6(29):271-390.

MORDOFF, R. A. 1949. The climate of New York State. Cornell Univ., Ext. Bull. 764.

MORTON, G. H., AND E. L. CHEATUM. 1946. Regional differences in breeding potential of white-tailed deer in New York. Jour. Wildl. Mgt. 10(3):242-248.

STATE BOARD OF EQUALIZATION AND ASSESSMENT. 1970. Population census by city, town and county. N.Y.S. Executive Dept., Albany, N.Y.

SMITH, R. H. 1954. A history and definition of game ranges in New York State. New York Federal Aid in Fish and Wildlife Restoration Project W-23-R (final report). N.Y.S. Cons. Dept. (mimeo.)

_____ 1955. Definition of game range divisions in New York. N.Y. Fish and Game Jour. 2(2):127-141.

STOUT, N. J. 1958. Atlas of forestry in New York. N.Y.S. Coll. Forestry, Bull. 41.

EARLY HISTORY OF THE ATLANTIC SALMON IN NEW YORK[1]

Dwight A. Webster Professor of Fishery Science
Department of Natural Resources
Cornell University, Ithaca, N.Y. 14853

ABSTRACT

The early abundance of Atlantic salmon in New York waters draining into eastern Lake Ontario is attested in the accounts of 17th, 18th and early 19th century observers. Of particular interest is the journal kept by DeWitt Clinton in 1810 during his trip by boat up the Mohawk River and down the Oswego River to inspect the route of the contemplated Erie Canal. Illustrative excerpts from this and other accounts are compiled together with comments by the present author in the light of current knowledge. Information concerning salmon in Lake Champlain and the Hudson River is also included.

PROLOGUE

"The narration of the previous abundance of the salmon in Lake Ontario and its tributary streams reads like a romance. . ." So wrote Hugh M. Smith for the U.S. Fish Commission in 1890 (Smith, 1892:195). Consider the following sampling of 17th, 18th and early 19th century writings on the subject.

The Jesuit Fathers LeMercier and LaMoyne ascended the Oswego River in July 1654. They met Oneida Indians

> "with their canoes filled with fresh salmon. . . one of our men caught twenty large salmon, and on the way up the river our people killed thirty other salmon with spears and paddles. There were so many of them that they were struck without difficulty" (Jesuit Relations and Allied Documents, 1899:151).

Another early account is found in the Van der Kemp Papers and pertains to the year 1792.

> "Both Salmon Rivers, emptying into Lake Ontario. . . and the Fish-creek in Oneyda Lake are in the spring and fall [full] of Salmon. You may form of this assertion, a pretty accurate opinion after I have informed you, that one Oneyda Indian took with his Spear 45 Salmons within an hour; another in the presence of Captain Simonds 65 during one night, and another 80" (Van der Kemp, 1880:64).

In 1817, one Elisha Clark built a dam across the Genesee River at Rochester. Thousands of salmon were killed by people using clubs, spears and pitchforks on the salmon that collected below the dam (Follett, 1932:367). The following also attest the abundance of this species in the early 1800's.

---

[1] The Onondaga Historical Society of Syracuse and the DeWitt Historical Society of Ithaca have been helpful in locating some early documents. My colleagues, Drs. John Forney and Edward Mills of Cornell University, have read and commented on the manuscript; and special thanks are due Dr. Vianney Legendre of the Quebec Ministry of Tourism, Hunting and Fishing for a critical review and remarks on the origin of salmon in Lake Champlain. Barbara Little assisted with some of the literature search.

"In October, 1836, two men took [on the Salmon River at Pulaski] two hundred and thirty Salmon between 8 p.m. and 12, with spears and fire-jacks, and after 12 till morning two other men in the same skiff took two hundred odd, the average weight of the entire lot being fourteen and three-quarters pounds. We have had fifteen hundred fresh Salmon in the fish-house at one time. When a freshet occured [sic] in June a few would always come up, and sometimes a few early in the spring. Any time from June till winter when there was a freshet they were sure to come. The principal time, however, was in fall, during September, October, and November. Twelve skiffs in one night have taken an average of three hundred Salmon each" (Goode, 1884:473).

"It was nothing uncommon for teams fording the rivers and creeks at night to kill salmon with their hoofs. An older settler living in the town of Hannibal told Mr. Ingersoll that one night while driving across Three-Mile Creek the salmon ran against his horses' feet in such numbers that the horses took fright and plunged through the water, killing one large salmon outright and injuring two others so that they were captured. The farmers living near the smaller creeks easily supplied their families with salmon caught by means of pitchforks" (Smith, 1892:196).

"My father and Uncle Asa. . . for a number of years could catch every fall from 15 to 20 barrels of salmon. . . They would come up the creek sometimes as early as September and then would be very fat. . . The largest that I ever saw caught in Salmon Creek weighed 32 lbs. and the largest I ever saw was caught in Salmon River; it weighed 42 lbs after it was dressed and was sold for §1.00. . ." (Simpson, 1949:176).

"Salmon were so abundant that men stood on the log across Salmon Creek and speared them with pitchforks in the 'fish-shoal'. Women often caught a salmon with their hands or in their aprons" (Simpson, 1949:154).

"Forty years ago the salmon fisheries on this [Salmon] river brought more money to the people than all the machinery now on the river" (written by a Mr. Cross and quoted by Goode, 1884:474).

Similar eloquent documentation of salmon abundance on the Canadian side of Lake Ontario can be found in contemporary Canadian publications (Parsons, 1973).

INTRODUCTION

The life history of the Atlantic salmon *(Salmo salar)* begins in the streambed as an egg buried under several inches of gravel. The eggs incubate there, and the fry that hatch in late winter or early spring develop until the yolk sac is absorbed. At this time the fish moves into the open water to begin feeding. After a variable length of stream life, usually one to three years but six or more in the far northern parts of the range, the salmon assumes the silver livery of a smolt and descends to the sea, usually during early spring. The body chemistry changes, not only to accommodate the move from fresh to salt water, but also to stimulate an enormous capacity for growth. Salmon that do not move far from the coast return to natal rivers after one winter in the sea as "grilse", usually 3 to 6 pounds in weight. Fish that go to distant feeding grounds remain at least two winters in the sea before returning at substantially larger sizes. The homing instinct is strongly developed so that straying is minimal and most individuals return to the same parts of the stream system in which they were born. There is one important exception to this generalized life history —salmon that complete the cycle entirely in fresh water. These are so-called "landlocked" salmon, but the term is a misnomer because nothing

prevents their descent to the sea. Either "freshwater salmon" or "lake salmon" is a more appropriate name (Legendre, 1966).

Given this background, consider the historic association and contribution of the Atlantic salmon to New York State and neighboring areas. The species colonized fresh waters throughout its natural range but is most widespread in eastern North America. In the western Atlantic, sea salmon formerly ascended rivers to spawn from Connecticut north to Ungava Bay. Following the last glaciation, populations remained in certain fresh waters, mostly lakes, southward as far as Maine, as well as up the St. Lawrence River and through Lake Ontario. These stocks represented a return to the ancient ancestral habitat since salmon originated as a freshwater species and must return there to reproduce.

Lake Ontario and certain lesser lakes tributary to the St. Lawrence River represented the most striking worldwide example of freshwater colonization by the Atlantic salmon. In New York, salmon invaded the interior waters of the Oswego River system: Seneca, Cayuga, Oneida and Onondaga Lakes. From the St. Lawrence, populations became established in the Lake St. John/Saguenay River system on the north shore, and to the south sea salmon, at least, used tributaries of Lake Champlain for breeding. But our legacy in the Atlantic salmon in New York State and the Province of Ontario disappeared well over a century ago, an inevitable consequence of rapid settlement by the colonists of North America.

Records of early settlers attest to the abundance of salmon in Lake Ontario for the fish was an important item of subsistence and for export. A complex life history pattern existed in the Oswego River system, unrivaled elsewhere in either freshwater or sea-run populations. An important, though unrecognized, historical source of information on salmon in New York is found in writings of a famous citizen of the State, DeWitt Clinton. Mostly remembered as an early governor, statesman and major proponent of the Erie Canal, Clinton was also an astute naturalist. The overview on the life history of salmon in the Oswego system is based on his notes and observations in 1810 when he journeyed westward by boat from Schenectady up the Mohawk River and down the Oswego to inspect the route of the contemplated canal. Following are excerpts from his journal (Campbell, 1849:27-204), mostly in chronological order, with comments by the present author as appropriate. The principal points of interest in the Oswego drainage are noted in Figure 1, and those elsewhere in the State are shown in Figure 2.

THE CLINTON CANAL JOURNAL

The first journal reference to salmon (p. 55) was at Rome on July 12 where the noontime repast was on a fish caught in Fish Creek. Rome was the site of historic Fort Stanwix and the divide between the Mohawk-Hudson and the Oswego-Ontario watersheds. He then noted that a salmon

Figure 1. Oswego River system showing inland lakes identified with migrant populations of Atlantic Salmon (in black) and streams historically mentioned as used for spawning (stippled). Adapted from frontispiece map in A Biological Survey of the Oswego River System (Anonymous, 1928).

had been speared in Mohawk waters at Rome, having crossed the divide via the 1¾-mile artificial sluice connecting the two systems, and remarked (p. 56) that

> "It would not be a little singular if the Hudson would be supplied with salmon through that channel".

The reference was to the absence of the species in the Hudson River—but more on that later. The company spent the night of the 12th at Gilbert's Tavern, 6½ miles by water west of Rome, where the proprietor

> "had procured fresh salmon from Fish Creek for us, at 6d a lb. We found it excellent" (p. 58).

This tavern was located near Canada Creek, a major tributary of Wood Creek flowing from the north. James Cockburn, who surveyed the tract in 1792, noted that

"The salmon comes up the Canada Creek about three miles in June; they are likewise caught in November. There was a weir formerly at the mouth of the creek where numbers were caught; it is now down" (Editor's Notes in Van der Kemp, 1880:113).

The next day, still travelling down Wood Creek, Clinton noted that a salmon had been speared on a boathook by a boat passing under a bridge.

"The frequent passage of boats, and the shallowness of the waters, terrify the salmon from ascending in great numbers beyond this place (p. 61).

"Fish Creek enters Wood Creek, a mile from the [Oneida] lake, on the north side. It is much larger and deeper, and derives its name from the excellent fish with which it abounds, up to the Falls, which are ten miles from its mouth. It is frequented by great numbers of salmon; and we saw Indians with the spears at work after that fish, and met two canoes going on the same business, with their pine knots and apparatus ready for the attack. The Indians have reserved the land on each side of this creek, in order the secure themselves the benefit of fishing" (p. 62).

Supper that night was at Mrs. Jackson's tavern at the eastern end of Oneida Lake near the mouth of Fish Creek.

"A number of canoes darting through the lake after fish in a dark night, with lighted flambeaux of pine knots fixed on elevated iron frames, made a very picturesque and pleasing exhibition. . . Here we met with an Indian canoe, filled with eels, salmon, and a monstrous cat-fish. . . On returning to the house, we found an excellent supper prepared; the principal dish was salmon, dressed in various ways" (p. 62).

Note that salmon composed three of the four main meals for these two days.

"The salmon come into this lake in May, and continue till winter. They are said to eat nothing. This is the season of their excellence. They formerly sold for one shilling a-piece; now the current price is sixpence a pound. The salmon are annoyed by an insect called a tick, and run up into the cold spring brooks for relief" (p. 62-63).

The reference here may be to a copepod parasite, *Salmonicola* (?), but movement into cool water seems more likely to have been to avoid high lake-water temperatures. In a later account, Clinton (1822:169) clarified the matter by stating that the parasites

". . . fix on the gills and fins, and eat the latter so that the fish can hardly swim."

Clinton mentioned another tributary of the lake, Oneida Creek, entering on the southeast and used by salmon for spawning as far up as an impassable falls at Stockbridge (p. 64). Canaseraga Creek formerly flowed into Oneida Lake from the south at Bridgeport and had a run of salmon up the Chittenango branch as far as the Falls (Fairchild, 1903:129 quoting correspondence between Van der Kemp and Clinton in 1817). The drainage pattern of the Canaseraga was subsequently moved eastward by dredging (J. Forney, personal communication).

On July 14

"We stopped at a house at the north side of the lake, in the town of Bengal [now Vienna according to the Onondaga Historical Society]. . . The family were eagerly engaged in the salmon fishing, and they told us that they sometimes caught with the seine one hundred per day; that fifteen fill a large barrel, for which they ask twelve dollars in salt. . . The salmon frequently weighs twenty pounds" (p. 66).

"As we approached Rotterdam [now Cleveland according to Jackson, 1963:91], we saw a seine drawn at the mouth of a small cold brook, and six salmon caught in a haul."

The party slept at Stevens', at the outlet of the lake, now Brewerton.

"Here commences Onondaga or Oneida river. . . Several Onondaga Indians were here. Numerous boats, traversing the river at night for salmon, and illuminated with fine flambeaux, made a brilliant appearance. . . Black raspberries grow wild in great abundance. They composed, with fresh salmon, the principal part of our supper" (p. 67-68).

The group started the descent of the outlet on July 15 and spent the night at Three Rivers Point where the Seneca River joined the Oneida to form the Oswego.

"Two or three miles farther we passed a rapid, called Horseshoe Rapid."

Breakfast on the 16th was at the foot of the rapids

"at a fine cool brook on the north side [and] consisted of common bread, Oswego bread and biscuit, coffee and tea, without milk, butter, perch, salmon and Oswego bass; fried pork, ham, boiled pork and Bologna sausages, old and new cheese, wood-duck, teal and dipper. Some of these, luxuries as they may appear on paper, were procured by our guns and fishing tackle, on our descent" (p. 73).

"In a smart shower, we arrived at the celebrated Falls of Oswego, twelve miles from Three-River Point, and twelve miles from Oswego. There is a carrying place of a mile here. . . loaded boats cannot with safety descend the Falls, but light boats may, not withstanding the descent is twelve feet, and the roaring of the troubled waves among great rocks is really terrific. . . The river downwards is full of rapids. . ." (p. 74-75).

It seems that some of the pools and jumping places at Oswego Falls may have been of some size and depth, judging from the description by Bartram (1895 [1751]:47-48) of spears used by the Indians fishing there in 1743.

"They strike them [salmon] with long slender shafts 18 or 20 feet long, pointed at the end with iron. The 2 splints of wood spreading each side, directs the point into the fish, which at a great depth it would otherwise be difficult to hit. I saw upon one of their canoes in the morning a large piece of bark spread across. On this lay gravel and sand, and on these coals and ashes, which I supposed had been a fire, and the gravel placed there to save the bark. And I took it to be a design both to allure and see to strike the fish."

A blacksmith, Daniel Masters, had located at the falls in 1793 and according to Simpson (1949:159) made spear heads to kill salmon that he sold for a silver dollar each.

On July 17, in Oswego, Clinton learned that

"Salmon have been caught at Van Valkenburgh's [a tavern two miles below Oswego Falls] in every month of the year. They sometimes weigh 37 pounds. The boats frighten them away, and as they are very shy, they are not so numerous as formerly. In the spring of the year they are in the best order. Big Salmon [Salmon River at Pulaski] is their favorite haunt. . . The salmon pass Oswego in April, in great numbers, and are caught at that time. In September and October, when they return to the lake, they are again caught; but at this season none are to be procured" [i.e., at the mouth of the Oswego] (p. 78-79).

In a later publication (Clinton, 1815a:147) he remarked that the returning fish were "much reduced in size and fatness".

Inquiries made of fishermen at a later date (Smith, 1892:195) provided more explicit information about the season of migration.

"There was an advent of salmon in the Oswego River which was called the 'June run'. This was usually two or three weeks earlier than the appearance of the fish in the Salmon River. In inland lakes in which the Oswego rises [Oneida, Onondaga and the Finger Lakes] kept that river well filled most of the time, but the Salmon River was ordinarily low when the salmon first came on the shore."

Smith's informants also stated that the salmon

"approached the shores in June and, if the water was sufficiently high, went up the streams to their head waters. . ."

Numerous records indicated a second migration of salmon, usually in September.

Returning up the Oswego, Clinton took the Seneca River westward at Three Rivers. A mill dam had been erected at Baldwins [now Baldwinsville] and he noted that

> "the apron of the dam does not appear to be calculated to promote passage of fish" (p. 89).

and the local tavern keeper

> "thinks that Baldwin's dam has injured the salmon fishery" (p. 93).

And again

> "we were told. . . that before the erection of Mynderse's and Baldwin's mill dams [both on the Seneca River], salmon was in considerable plenty, but that since they have been scarce" (p. 100).

Salmon turning into the Seneca River were destined for Onondaga, Cayuga or Seneca Lakes. Clinton, perceptive about possible consequences of blocking the movement to natal spawning grounds, brought the matter up again as he detoured through Ithaca on his return to Albany.

> "Salmon frequented this lake [Cayuga] the latter end of August and continued until cold weather. Last year [1809], since the erection of Baldwin's mill dam across the Seneca River, they did not appear until October, and then not in the usual number. Some have always continued over the winter, and are caught by openings in the ice, with a hook and a bait of pork or white worm" (p. 162).

Clinton did not mention the presence of salmon in Seneca Lake, but it can be inferred because they were reported in the Seneca River west of Cayuga Lake at Seneca Falls. Authentic records of salmon in both Seneca and Cayuga Lakes were left by the Jesuit Fathers who traveled the area in the mid-17th century. Salmon spawned in Catharine Creek, the inlet of Seneca Lake, and in Cayuga Inlet and Salmon Creek, tributaries of Cayuga Lake. An Ithaca pioneer, Nehemiah Woodworth, said of the early winter in 1788

> "From the inlet [of Cayuga Lake], they also took, by spearing. large quantities of salmon of large size, which were accustomed to go up several miles from the Lake" (Webster, 1958:29).

Onondaga Lake was also visited by salmon, as indicated by Father LeMoyne during his visit in 1654 (quoted by Beauchamp, 1908:44). Additional verification lies in a colorful report by a contemporary of Clinton's, Thurlow Weed who later became a printer in Syracuse.

> "In the spring of 1810, with two other boys, I was walking of a pleasant evening in the vicinity of the Onondaga creek [i.e., inlet of Onondaga Lake], a mile and a half south of the site of the present city of Syracuse. . . Our attention and surprise were excited by seeing bright lights moving, as we supposed, along the banks of the creek. On approaching, however, we discovered Onondaga Indians with pine knot torches and clubs, killing salmon, whose fins and backs were seen as they were ascending the creek in shallow water over the rifts. The Indians good naturedly lent us clubs and gave us the benefit of their torches, until each had captured a salmon, with which we departed for our homes in jubilant spirits. Most of the inhabitants of Syracuse will find it hard to believe that salmon were ever taken south of that city" (Beauchamp, 1908:46).

In other parts of the journal Clinton did not mention salmon in Canandaigua Lake, Owasco Lake or Skaneateles Lake and, because he did refer to fish life and good trout streams in his discourse relative to Auburn and the town of Skaneateles, we can confidently assume that salmon did not ascend to these waters. The outlets of these minor Finger Lakes also flowed into the Seneca River so it may be supposed that the natural barriers mentioned by Clinton prevented the ascent of salmon. Another early writer (Clark, quoted by Beauchamp, 1908:47) recounted clubbing salmon on the riffles of Skaneateles Creek, so at least they used accessible reaches of this stream for spawning. Keuka Lake, a tributary of Seneca Lake, has an impassable cascade near its mouth.

SALMON IN THE NEW YORK DRAINAGE OF LAKE ONTARIO

Given contemporary knowledge of salmon biology, the fragments of information recorded by Clinton and others provide a meaningful picture of salmon in the Lake Ontario system in general and the complex Oswego drainage in particular. They moved into this river through the spring and again in early fall, disseminating into a network of headwater tributaries. Migrating adults intuitively made a choice at Three Rivers Point to take the Oneida River eastward to Oneida Lake or the Seneca River westward to Onondaga, Cayuga and Seneca Lakes. Further discrimination was required to reach the home lakes and individual natal spawning streams.

Distances travelled to the spawning gravels after leaving Lake Ontario were considerable — some 70 miles for the trip to the headwaters of Wood Creek at Rome or 100 miles into the inlets of Cayuga Lake at Ithaca or Seneca Lake (Catharine Creek) at Watkins Glen. The role played by these lakes in the life history strategy of these particular races will never be known. In Oneida Lake it is clear that salmon summered in the lake as well as in the tributaries. That Oneida was warm and pea green with algae, then as now, cannot be doubted from Clinton's description in 1810

> "The waters of the lake were saturated with small dark atoms, which render them unsalubrious, and when drank, operate emetically, and produce fever" (p. 64).

The two Finger Lakes, on the other hand, would have provided cold waters in which to pass the summer months. Sea salmon are known to use lakes as well as streams in this way.

The evidence is against distinct populations of salmon with continuous residence in the interior New York lakes. In Cayuga Lake the effect of the dam on the Seneca River at Baldwinsville was noted immediately, suggesting that young salmon produced in the tributaries of this lake returned to Lake Ontario for growth to maturity. Populations in the interior lakes collapsed once access by fish from Lake Ontario was denied despite the fact that spawning tributaries were not cut off by dams.

In Lake Ontario, the source of salmon in the Oswego system, historical

records are adequate to fix the presence of spawning fish in every major tributary except the Niagara River, i.e., at least 25 streams on the Canadian side and 15 in New York (Parsons, 1973:8). From east to west the latter were: Chaumont River, Black River (Jefferson Co.), Stony Creek, Big Sandy Creek, Sandy Creek (Oswego Co.), Deer Creek, Salmon River (Oswego Co.), Grindstone Creek, Little Salmon River, Oswego River, Three Mile Creek, Salmon Creek, Genesee River, Sandy Creek (Orleans Co.) and Twelve Mile Creek (Figure 2). The Salmon River, discharging at Pulaski, supported the largest run on the American side. The Credit River, at the western end of the lake near Toronto, was the major Canadian salmon stream.

Present knowledge on homing of salmon to parent streams permits the assumption that fish migrating into these streams were discrete stocks. Direct evidence for this in New York is scanty, but it may be indirectly inferred from the observations of an informant quoted by Goode (1884:474) who said

> "There were formerly three salmon streams in this vicinity — Grindstone Creek, Deer Creek and Salmon River — and each stream had a different type of fish. An experienced fisherman could readily tell from which stream a fish was caught, though they are but four miles apart. In Deer Creek the fish were long and slim, in Grindstone short and chubby, and in Salmon River large and heavy."

Early marking experiments, described under a later topic, also provide direct evidence. Then there is the special case of the Niagara River.

Mystery of Niagara

The Niagara River contained the discharge of the four Great Lakes above Ontario but was not visited by salmon although by volume it dwarfed all other tributaries. In colonial days, this aroused curiosity and controversy. Clinton (1815b:497-500) addressed the problem in a dissertation entitled "Fishes of the Western Waters of the State of New York" (reprinted with annotated comments in Webster, 1980:10-12). A Dr. Barton, whom Clinton quoted, had offered several possible explanations of why salmon did not ascend the Niagara that included inherent knowledge of the barrier imposed by the falls, differences in water temperature or quality and noise of the falls. Barton favored the latter as the most probable deterrent. Clinton took issue with all these possibilities and systematically countered each, pointing out in conclusion that salmon migrated into streams for purposes of spawning and that the Niagara River being

> "destitute of these accomodations. . . the salmon does not resort to it for the purpose of propagation."

Clinton was familiar with marking studies conducted in Europe suggesting that young salmon returned to the rivers of origin, and he intuitively deduced the correct reason for absence of salmon in the Niagara River.

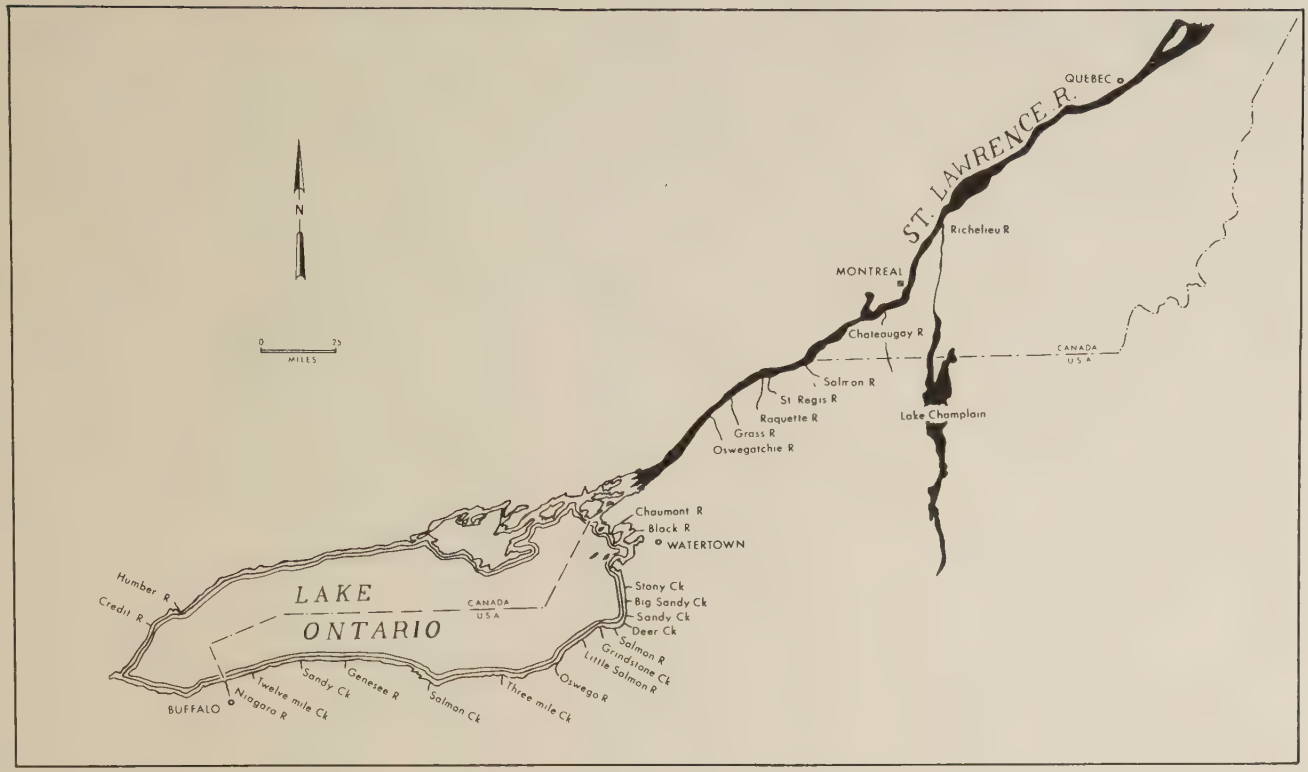


Figure 2. North- and west-flowing streams in the Lake Ontario/St. Lawrence drainage frequented by Atlantic salmon in New York (Niagara River excepted). Redrawn in part from Parsons (1973).

Size

The size of salmon in Ontario waters compared favorably with that of sea fish. Clinton's account, already quoted, suggested that the maximum size for the Oswego River was 37 pounds and noted that 20-pounders were frequent. In a later paper (Clinton, 1822:169) he stated of the lake salmon in general that the greatest weight was 48 pounds. Some years later, Atkins (1884) examined about 200 fish from the Salmon River (Oswego Co.) that ranged from 1 to 45 pound, averaging almost 15. These and other statistics are impressive, but not unique for freshwater stocks of *Salmo salar*. Fish commonly reached 10 to 20 pounds in Sebago Lake in Maine with maximum sizes up to 35 pounds (Kendall, 1935), 25 pounds in Vänern in the southern tip of Sweden (Runnström, 1940) and 22 pounds in Lake Ladoga on the Russo-Finnish frontier (Berg, 1962:243).

Origin

The origin of salmon migrating into tributaries of Lake Ontario has been pondered by most writers about salmon in this watershed. Clinton (1822:167) considered they were resident in the lake.

> "This fish, it is said, is caught all the year in the lakes [Ontario and interior New York waters]; perhaps some of them remain without ever returning to the ocean. . . They have never been observed at Ogdensburg. . . The received opinion is that they are naturalized to the lakes, and stay all the year."

Although DeKay (1842:242) examined specimens from Oneida Lake he was not informed on their life history and so made an erroneous intuitive deduction.

> "They are occasionally found in Lake Ontario during the whole year, but as the same instinct which impels them to ascend rivers, also leads them back again to the sea. . . we may presume that these are sickly or possible barren individuals."

The scarce evidence available supports Clinton's view, although this does not rule out the possibility that sea-run fish also entered the lake from the St. Lawrence. Parsons (1973:11-12) reviewed the available literature and considered that both types were present. A compelling argument for a freshwater resident stock was the early spring date of some runs into rivers (Huntsman, 1944:89). It was unlikely that sea salmon could move up so quickly after the ice left the St. Lawrence and arrive in the prime condition noted in the Oswego River in New York (Clinton, 1815a:147) and in the Credit River and Humber River in Canada (Fox, 1930:46; Wilmot, 1872:79).

Salmon had disappeared from Lake Ontario long before fishery science had developed to a stage where biological studies could firmly determine the relationships of various stocks of resident and/or anadromous strains. Scales obtained from two museum specimens from this water indicated a growth pattern of fish that had never been to sea (Blair, 1938). The only

marking experiment was conducted by the contemporary authority on the salmon of Lake Ontario, Samuel Wilmot, a Canadian. He marked salmon by finclipping in three northshore tributaries in 1868-1871. Most of the recoveries (summarized by Huntsman, 1944:88) were made after a time lapse of two years in the same stream where the fish had originally been marked. The data confirmed the strong homing instinct expected of salmon and suggested alternate-year spawning, but they conveyed little information about the origin of salmon in Lake Ontario since there had been little effort to examine fish captured in the St. Lawrence River.

The proximity of runs of sea salmon migrating up the St. Lawrence enhanced the possibility that some continued on to enter Lake Ontario where they may have used some tributary streams for breeding.

> "At Cape Vincent they were formerly taken on the lake shore during migrations. Never went up Chaumont Bay. No rivers to spawn in. Never seemed abundant in the Saint Lawrence only as they passed by" (McPherson, quoted by Goode, 1884:474).

This information only places salmon in the area, but provides no clue as to their origin. Legendre et al. (1980) expressed the opinion that sea salmon did not contribute to Lake Ontario stocks, suggesting that they did not ascend the St. Lawrence above Quebec City. But Edmunds (1874:627) listed various south-shore tributaries of the river in New York as having had historical spawning runs, including the Oswegatchie, Grass, Raquette, St. Regis and Chateauguay Rivers. Fox (1930:54) mentioned a letter by one W.D. Lighthall "concerning the annual run of salmon in the Chateauguay River". It is a curious omission that the Salmon River in Franklin County is not included in the list.

SALMON IN LAKE CHAMPLAIN

Apparently salmon in Lake Champlain were sea fish, running the Richelieu River from the St. Lawrence and then ascending lake tributaries for spawning. Clinton (1822:168) wrote

> "In Champlain river [presumably the outlet Richelieu, but this is only supposition and it could be Clinton's name for the Great Chazy River that flowed through the settlement of Champlain] there is no dam for seven miles, and salmon go in about the middle of April, and are good till the first of June. The Little [Au] Sable River has plenty, and also the Great [Au] Sable, because there are no mill dams. . . This fish does not ascend the Champlain Lake above [i.e., south of] Ticonderoga."

He reported that a mill dam on the Saranac River at Plattsburgh had destroyed the exceptionally abundant salmon run there. Much of the other published information available is contained in two reports to the U.S. Commission of Fish and Fisheries (Edmunds, 1874; Watson, 1876), that agency being interested in locating obstructions on the rivers entering Lake Champlain and in documenting verbal reports of earlier abundance and habits of the fish. At the time the material was compiled, salmon had been extinct in these waters for several decades.

"The progress of the salmon in their annual migration from the sea to the tributaries of the lake [Champlain] seems to have been singularly slow and methodical. Instead of diffusing themselves at once and promiscuously through the lake, the advance from the north was apparently controlled by a system or some law of instinct. The old fishermen all concur in the recollection that a considerable interval, varying in their statements from one week to a month, always occurred between the time of arrival of the fish in the Saranac and their appearance in Au Sable. . ." (Watson, 1876:538).

On the Vermont side, Otter Creek was the most southerly stream formerly visited by salmon and the Winooski, Lamoile and Missisquoi Rivers were all considered exceptionally fine salmon streams. On the New York shore there were the Bouquet, Salmon, Saranac, and Little and Big Chazy Rivers. Where it runs into Lake Champlain, the latter stream it designated as "Salmon fishery" on a colonial map of 1779 (reproduced by Moore, 1930:18-19). She also quoted 1791-92 account-book records of a store in the settlement of Champlain where salmon were offered for barter in the months of January, March and May, and from July through November. Some of the fish were preserved so it cannot be inferred that fresh salmon were available in January and March (specified as salted), a point bearing on whether sea or freshwater salmon were involved. One entry showed 45 salmon accepted in lieu of a barrel of suckers and another that two barrels of salmon exchanged for one-third of a cow.

Edmunds spent some time on the Richelieu River and found no serious barriers for ascending fish in 1872. He wrote (Edmunds, 1874:626-627) that eel weirs

"would doubtless afford no serious objection to the early run of salmon, but for the late run of shad or salmon, they would prove a great barrier."

He noted that smelt moved up and down the river and concluded that if this were possible

"no serious impediments exist to the ultimate success of restocking Lake Champlain. . ."

Legendre (personal communication, June 25, 1981) pointed out that there are no known historical records of salmon caught in the Richelieu River, casting doubt on whether the Champlain fish were in fact sea run. However, apparently authentic records of salmon in the St. Lawrence River above Montreal have already been noted for the Chateauguay River and elsewhere (Parsons, 1973:6-8).

Testimonials to the abundance of salmon in Lake Champlain rival those for Lake Ontario. At the time Benedict Arnold was cruising the lake in 1776 with an American Flotilla, a fisherman, William Gilliland, presented him with 75 salmon in return for which he requested assistance of the ship's carpenter to repair his washed out salmon traps. Gilliland also mentioned in a letter to the Congress in 1777 that he "had complimented the American Army with fifteen hundred salmon in one year."

Watson (1876:533) reported that

"it was a common pastime, as well as a most desirable means of obtaining food at that time, to drive a team into some of the shallow tributaries of the river, and from the wagon spear the salmon with pitchforks, and thus obtain in a few minutes all the fish needed for consumption."

He also noted that when salmon were migrating it was considered unsafe to ride a spirited horse into them and that the passage of a wagon might be impeded by the numbers of salmon in the stream.

> "Mr. Fouquet, the proprietor of the Fouquet Hotel in Plattsburgh, informed me[in 1872] that his grandfather related the fact that he had seen immense schools of salmon making into the mouth of this river [Saranac] in his day, in such abundance as to completely fill the river, rendering their capture by the cart-load as easy matter. . . A Mr. Jones. . . informed me that so plenty were the salmon in an early day that a twenty-pounder could be bought for a 'plug of tobacco'" (Edmunds, 1874:624-625).

SALMON IN THE HUDSON RIVER?

The Connecticut River was famous for salmon in colonial days, and the species even frequented the Housatonic River some 50 miles due east of the Hudson River (Kendall, 1935:78). Rumors that salmon once inhabited the Hudson stem from Hendrik Hudson's original account of 1609, where he reported seeing them off Sandy Hook in September and again as he passed upstream through the Highlands. But Dr. Samuel Mitchill, pioneer American ichthyologist of New York City, was explicit on the subject in his "Fishes of New-York" (Mitchill, 1815:435). Salmon, he said, had never been observed there in colonial times and fish frequently encountered in commercial nets were only strays from other streams. DeKay (1842:242) again only confused the situation by accepting the Hudson record literally, noting, in connection with one taken at Troy in 1840

> "The Sea Salmon rarely now appears on our coast, except as a straggling visitor. . . Previous to the setting of so many nets along the whole course of this river, it is probable that salmon were more numerous."

Since he did not refer to Mitchill or other contemporary writers one must conclude that DeKay's information was superficial and not to be given credence when considering the question of salmon in the Hudson.

DeWitt Clinton (1815a:148-153) researched the subject of salmon in the Hudson River and after reading the Journal of Hendrik Hudson came to the conclusion

> "Hudson certainly did not intend the common salmon. I believe, that the fish he meant, is our rock fish or streaked [striped] basse, which comes into the river about that time, in great numbers."

Clinton also quoted a "Natural History of New Netherland" written in 1655 by Adrian Van den Donk, M.D. who referred to the great abundance of waterfowl and game in the area and said that

> "the fishes are in the greatest plenty: streaked basse, shad, sturgeon, sea basse, black fish, herring. . ."

It is, perhaps, significant that salmon did not appear on the list.

The Hudson River lacked the necessary spawning and nursery capacity to maintain salmon. The first major tributary, the Mohawk River, entering from the west above Albany, was impassable due to the 70-foot falls at Cohoes. Upstream movement on the main stream was blocked at Hudson

Falls, some 50 miles north of Albany. Below these natural barriers the tributaries were small and usually impassable due to falls close to the Hudson. Maintaining a stock of Atlantic salmon in such a large river would require great production of young to offset the toll exacted by predators during the years of stream life, the downstream journey of the smolts to the ocean and one or more years of sea life.

An attempt to establish salmon in the Hudson was made by the U.S. Fish Commission in the 1880's, recognizing that the lack of suitable spawning grounds was the probable cause for its absence in that river (Cheney, 1887:351; Mather, 1889:409). A small planting was made in the Vermont portion of the Battenkill in 1880, followed by releases of about 2½ million fry in the headwater tributaries, mostly in Warren County (N.Y.). Young salmon did well in one of these streams, Clendon Brook flowing into the Hudson from the east 5 miles north of Glens Falls. Fred Mather, who worked for the N.Y.S. Fish Commission and was superintendent of the new fish cultural station at Cold Spring Harbor, recovered parr by angling there. In 1888, Mather (1889:418) tracked down numerous reports of salmon from the Hudson, arriving at a total of 134. The task of soliciting information on the catch was not easy because a law had been passed the year before making it illegal to take salmon in New York waters except by hook and line. As salmon were mostly caught incidentally in shad nets, fishermen were suspicious about inquiries on this subject and hence the reported catch was believed conservative. Most of the salmon recorded were from estuary waters, Gravesend and New York Bays, but at least 30 were captured at the dams at Mechanicville and Troy. A dam at the latter location had been built in connection with the Erie Canal and further penetration upstream was possible only in high water.

ANGLING FOR SALMON

Clinton noted in the Canal Journal (Campbell, 1848:63) that the salmon were reported to eat nothing while in Oneida Lake. Subsequently (Clinton, 1822:168-169) he wrote

> "Salmon have been caught in the Oneida Lake, and Lake Champlain, by the hook. . ."

He then described what can only have been a heavy emergence of the large mayfly, *Hexagenia*, adding

> "During this state of these insects, the salmon and other fishes fare luxuriously and disdain the hook."

An earlier traveler in 1792 had described the same phenomenon

> "We had now lost a great part of two days in fishing without an adequate reward to our exertions. . . but we soon discovered the cause of our failure. . . The Lake was now covered with a white cloak of hundred thousands millions of insects, which we call *Haft* in Holland, and which lay in some part of the shore one and two inches deep. This insect appears here annually at a stated period. . ." (Van der Kemp, 1880:71).

It is singular that Clinton did not try his hand at, or at least mention, angling for salmon. He was fond of trout fishing. According to one of his biographers, Dorothie Bobbé (1933:67), "He fished, relishing the sport in the nearby streams [of Long Island]." Clinton (1815a:150) shared a prevalent notion about salmon, stating that they were rarely caught except by spear or net. A mid-19th century writer on North American angling, H.W. Herbert (1851), mentioned salmon in Lake Ontario and the Finger Lakes but not in the context of sport fishing. Obviously the early settlers viewed the resource from the standpoint of subsistence, not recreation —— there were easier ways to get salmon than by hook and line.

Still it is tempting to let the mind's fancy play with the possibilities of a sport fishery on the Oswego or Salmon Rivers in those days. Just the names of the rapids of the Oswego conjure up inviting holding pools and runs. In his Canal Journal (p. 75) Clinton listed them from Oswego Falls downstream to the mouth: Braddock's Rift, Smooth Rock Rapid, Devil's Horn, Six Mile Rift, Little Smooth Rock Rapid, Devil's Warping Bars, Devil's Horse Race and Oswego Rift. Beauchamp (1908:48) wrote that

> "At Baldwinsville the Salmon Hole in the River [Seneca] is still well known; a deep spring hole where the great fish used to lie. On the bank nearby was a hollow log in which a lucky fisherman would place his surplus catch, for the benefit of any who came along."

Beauchamp's fisherman doubtless used a spear.

Champlain waters can boast of providing an authentic early report of sport fishing for salmon (Cometti, 1976:90). Lt. John Enys, in His Majesty's Service and quartered in Montreal, accompanied a party on an angling excursion to Lake Champlain in mid-May 1786. According to his journal they caught a few salmon in the mouth of the Chazy River, but their chief destination was the Saranac. They found a "Yankee Settlement" at the mouth, now the site of Plattsburgh.

> "Major Campbell took his Rod and very soon caught a fish. This was the first Salmon the people of the Settlement had seen here and they were equaly [sic] astonished to find those fish in the River and to see them caught with so Slender a Rod. They wished very much to see our Baits and it was not without some difficulty we made them believe that we caught them with the flies we shewed them. . . We had not very good success on the first day but it improved afterwards, so that we had as many Salmon as we could wish for ourselves, gave some to the Inhabitants and brought away twenty in Pickle."

Perhaps the record on angling should end on that esoteric plane, but an AuSable River account by Watson (1876:540) requires recognition.

> "he saw a man sitting in a boat at the head of one of the rapids. . . and drawing in salmon with great rapidity; that he cast a long line and a common hook baited with a piece of pork into the rapids, and that even before the hook touched the water the fish would seize it with the eagerness that is ofter displayed by the trout."

POSTLOGUE

DeWitt Clinton (1815a:152) enumerated early signs of loss of habitat for salmon and other fishes.

"The cultivation of the country has had a prodigious effect in producing this diminution. . . The cutting down of trees, the drying up of swamps, marshes, the ploughing of land, and the exposure of the soil to the influence of the sun, have lessened these sources of subsistence. The streams and rivers have also been diminished in size, some of them have been entirely dried up. The fountains and springs which furnished cool retreats for the deposite of their spawn, are destroyed. The alluvial deposites have also choked up their ancient places of resort, have discoloured the waters, and rendered them disagreeable and unhealthy; and they have thus been expelled from their former domains, and have been obliged to look out for other haunts, in wild and uncultivated countries."

A writer for the "New Topographical Atlas of Tompkins County, New York" had this to say of Cayuga Lake in 1866.

"many of our citizens can well remember the time, when from the waters of this lake [Cayuga], their tables were annually served that prince of fish, . . . the Salmon, with flesh as red and luscious as any taken nearer tide water; but to the great disgust of many, and regret of all, these excellent fish have been shut out from this lake by the reckless manner in which its outlet has been damed [sic], and its water polluted with the vile offal from Starch, Gas, and other Factories located near the stream" (Anonymous, 1866).

Salmon were essentially extirpated in Lake Champlain by the early 1800's and in Lake Ontario shortly after mid-century. The Province of Ontario attempted to reestablish runs in the 1860's, but success was limited and shortlived (Parsons, 1973:18-19). By the time Edmunds (1874:628) made his survey for the U.S. Fish Commission in 1872, he found only a single stream in both the Ontario and Champlain watersheds that still had a salmon to report—the Salmon River below the first dam at Pulaski.

In 1891, the U.S. Commissioner of Fish and Fisheries, Marshall McDonald, reported to the Senate (Smith, 1892:200)

"The cause of the disappearance, practically, of salmon from the streams of the St. Lawrence Basin has been chiefly and primarily the erection of obstructions in all of the rivers, which have prevented the salmon from reaching their spawning grounds, and so natural reproduction has been absolutely inhibited."

The extent of this kind of development on tributaries of Lake Ontario may be judged from an account by Horatio Seymour (1869:27-28) in the first Report of the New York Commission of Fisheries in which he noted: eight dams across the Salmon River below the falls, the lowermost 8½ feet in height; 27 dams on Big Sandy Creek, including both branches; seven dams on Little Sandy Creek; and 10 dams on the Oswego River, the first one 10 feet in height.

LITERATURE CITED

Anonymous. 1866. New Topographical Atlas of Tompkins County, New York. Stone & Stewart, Philadelphia.

_____ 1928. Frontispiece map. In: A Biological Survey of the Oswego River System. N.Y.S. Cons. Dept.:8.

Atkins, Charles G. 1884. Notes on land-locked salmon. Trans. Am Fish-Cult. Assoc. [Trans. Am. Fish. Soc.] 13:40-54.

Bartram, John. 1895. Observations on the inhabitants, climate, soil, rivers, productions, animals, and other matters worthy of notice. Made by Mr. John Bartram in his travels from Pensilvania to Onondago, Oswego and the Lake Ontario, in Canada. (London, 1751; reprinted, Geneva)

BEAUCHAMP, WILLIAM M. 1908. Past and Present of Syracuse and Onondaga County, New York. S.J. Clarke Publ. Co., New York.

BERG, LEO S. 1962. Freshwater fishes of the USSR and adjacent countries 1:214-248. (Translation Nat. Sci. Found., Wash., D.C.)

BLAIR, A. A. 1938. Scales of Lake Ontario salmon indicate a land-locked form. Copeia 1938(4):206.

BOBBÉ, DOROTHIE. 1933. DeWitt Clinton. Minton, Balch & Co., New York.

CAMPBELL, WILLIAM W. 1849. The Life and Writings of DeWitt Clinton. Baker & Scribner, New York.

CHENEY, A. N. 1887. Salmon in the Hudson River. Bull. U.S. Fish Comm. 6:351-352.

CLINTON, DEWITT. 1815a. An introductory discourse. Trans. Literary and Philosophical Society of New York 1:21-184.

_____ 1815b. Some remarks on the fishes of the western waters of the State of New-York (a letter to S.L. Mitchill, February 1, 1815). Trans. Literary and Philosophical Society of New York 1:493-501.

_____ 1822. Letters on the natural history and internal resources of the state of New-York. By Hibernicus (pseud.) Privately printed by Bliss & White, New York.

COMETTI, ELIZABETH [Ed.]. 1976. The American Journals of Lt. John Enys. Adirondack Museum, Syracuse Univ. Press.

DEKAY, J. E. 1842. Zoology of New York, Part IV, Fishes. White and Visscher, Albany.

EDMUNDS, M. C. 1874. Obstructions in the tributaries of Lake Champlain. Rept. U.S. Comm. Fish and Fisheries (1872-73):622-629.

FAIRCHILD, HELEN L. [Ed.]. 1903. Francis Adrian Van der Kemp, 1752-1829: An Autobiography, Together With Extracts From His Correspondence. G.P. Putnam.

FOLLETT, RICHARD. 1932. *Salmo salar* of the St. Lawrence River. Trans. Am. Fish. Soc. 62:366-368.

FOX, W. SHERWOOD. 1930. The literature of *Salmo salar* in Lake Ontario and tributary streams. Trans. Royal Soc. Canada, Sect. 2, Ser. 3:45-55.

GOODE, GEORGE B. 1884. The salmon — *Salmo salar*. In: The Fisheries and Fishery Industries of the United States. Sect. 1, Natural history of useful aquatic animals. U.S. Comm. Fish and Fisheries:468-474.

HERBERT, HENRY W. 1851. Frank Forester's Fish and Fishing of the United States. Stringer & Townsend, New York: Suppl. 3rd ed.:9.

HUNTSMAN, A. G. 1944. Why did Ontario salmon disappear? Trans. Royal Soc. Canada, Sect. 5, Ser. 3:83-102.

JACKSON, H. F. 1963. Scholar in the Wilderness, Francis Adrian Van der Kemp. Syracuse Univ. Press.

JESUIT RELATIONS AND ALLIED DOCUMENTS. 1899. Travels and Explorations of the Jesuit Missionaries in New France (1610-1791). Lower Canada, Iroquois: 1656-1657. Vol 43. (English translation edited by R.G. Thwaites) Burrows Bros. Co., Cleveland, Ohio.

KENDALL, W. C. 1935. The fishes of New England. The salmon family, part 2 — The salmons. Mem. Boston Soc. Nat. Hist. 9(1):166.

LEGENDRE, VIANNEY. 1966. Freshwater salmon in Quebec: The game fish of the future. Introduction and Part I, The name of the fish. Bull. Tourism, Fish and Game, Aug.-Sept.:27-29.

LEGENDRE, VIANNEY, J-R MONGEAU, J. LECLERC AND J. BRISEBOIS. 1980. Les salmonides des eaux de la plaine de Montreal. 1. Historique, 1534-1977. Rapt. Tech. 06-27. Ministrie du Loisir, de la Chasse et de la Peche, Que.

MATHER, FRED. 1889. Report upon the results of salmon planting in the Hudson River. Bull. U.S. Fish Comm. 7(1887):409-424.

MITCHILL, SAMUEL L. 1815. The fishes of New-York, described and arranged. Trans. Literary and Philosophical Society of New York 1:355-492.

MOORE, EMMELINE. 1930. Introduction. In: A Biological Survey of the Champlain Watershed. N.Y.S. Cons. Dept.:9-21.

PARSONS, J. W. 1973. History of salmon in the Great Lakes, 1850-1970. U.S. Bur. Sport Fish and Wildl., Tech. Paper 68.

Runnström, Sven. 1940. Comparative growth of lake populations of *S. salar* & *S. trutta* in Väner. Medd. K. Lantbruksstyrelsen Nr 18.

Seymour, Horatio. 1869. The salmon. In: Rept. New York Comm. Fish. 1:25-28.

Simpson, Elizabeth M. 1949. Mexico, Mother of Towns. J. W. Clement Co., Buffalo.

Smith, Hugh M. 1892. Report on the fisheries of Lake Ontario. Bull. U.S. Fish Comm. 10[1890]:195-202.

Van der Kemp, Francis A. 1880. Extracts from the Van der Kemp papers. From the Hudson to Lake Ontario in 1792. Buffalo Hist. Soc. 2:64, 113.

Watson, W. C. 1876. The salmon of Lake Champlain and its tributaries. Rept. U.S. Comm. Fish and Fisheries (1874-75):531-540.

Webster, Dwight A. 1958. Return to Cayuga. N.Y.S. Conservationist 12(8):29.

_____ 1980. DeWitt Clinton's ". . . Fishes of the western waters of the State of New-York" reexamined. Fisheries 5(2):5-12.

Wilmot, Samuel. 1872. Report of S. Wilmot, Esq., on the fish-breeding establishment at Newcastle, Ontario, during the season of 1871. [4th] Annual Rept. [Can.] Dept. Marine Fish. 1871. Append. 1:76-85.

PROVIDING WHITE CEDAR AS WINTER BROWSE FOR DEER WITHOUT INCURRING OVERBROWSING[1]

C. W. Severinghaus Severinghaus Wildlife Consultants
J. D. Severinghaus Voorheesville, N.Y. 12186

ABSTRACT

A means of using wire-mesh cylinders to protect young white cedars from overbrowsing by deer while at the same time allowing the deer to obtain a substantial amount of forage through the mesh is described. The quantity of browse that can be provided in this way and its importance to a deer population, as well as the costs involved, are discussed.

White cedar *(Thuja occidentalis)* is one of the most preferred of the winter browse species eaten by deer. Annual reports of the Adirondack League Club in the 1890's noted that deer were eliminating three species from the winter range: white cedar, American yew *(Taxus canadensis)* and witchhople *(Viburnum alnifolium)*. Elsewhere in the Adirondacks similar conditions were reported by Fox (1896:165) and Spiker (1933:336). Aldous (1941) rated white cedar the most important browse for white-tailed deer in the Lake States region. He reported that the supply had been gradually reduced and that many areas once covered by white cedar were, at that time (1940), devoid of it while others had stands where the browse line was so high that the forage was no longer available to deer. He also stated that white cedar could not continue to produce browse if more than 25 per cent of the foliage was removed annually. Davenport (1939) found that, to be maintained in good condition, deer needed about 4.8 pounds (fresh weight) or 1.98 pounds (dry weight) of white cedar per day per hundredweight of deer. Aldous (1941) recognized that white cedar would produce and thrive when protected by fence or when the deer population was reduced to a level where under 25 per cent of the annual growth was removed by browsing. In the spring of 1945 on Rockland Power and Light Co. property in Rockland County (N.Y.) the author saw a wooden board fence, erected each fall to prevent deer from destroying several hundred yards of white cedar hedgerow, where the deer were still able to browse on

---

[1] The author wishes to thank the following colleagues in the State Department of Environmental Conservation: Ralph Colson and Joseph Dell for encouragement and assistance during the early development of this idea; Ralph Smith for assistance in installing the original wire cylinders on the Partridge Run Game Management Area: and William Sharick and others in Region 4 for assistance in planting the white cedars and installing wire cylinders on the Blenheim-Gilboa area. Thanks are also extended to personnel of the Camp Summit facility of the State Department of Correction for clipping the wires to enlarge the mesh of the original cylinders on the study area, James Powers of the State University at Albany for assistance with statistical tests, and Dr. Aaron Moen of Cornell University for advice concerning procedures for determining the quantity of forage required by deer. Acknowledgement is made to Kent Gustafson, Jan Reisner and Susan Whittemore for assistance in analyzing data and for programming the computor used for calculations.

the cedar to a limited degree through the 6-inch spaces between boards. This seemed to do no serious damage to the hedgerow.

During the late 1930's and early 1940's white cedar seedlings were planted over hundreds of acres of abandoned land in the Southern Tier and northern peripheral Catskills of New York. Deer abundance was generally low (probably less than 10 deer per square mile in the fall) and many plantings survived. But wherever it was higher or there were substantial winter concentrations, the plantings never grew more than 2 feet tall and most were killed by overbrowsing. A few lived to be trees and in the early 1950's these showed a typical browse line 7 or 8 feet above the ground.

As a result of these experiences, the author concluded that white cedar hedgerows might be protected by wire-mesh fences that would exclude deer but still allow them to forage through the mesh. Such fencing was tested in the early 1960's on the Partridge Run Game Management Area in Albany County where personnel of the Department's Bureau of Game installed wire cylinders 2.5 feet in diameter and 6 feet high with 2 x 4-inch mesh around white cedars that had been planted about 1939. The cedars were no more than 2 feet tall at the time, but within four years they filled the cylinders and extended above the top. Deer ate all foliage growing through the fence but did not browse over the top of the 6-foot-high cylinders. An opportunity to explore this approach further was afforded on lands that had been purchased in the late 1960's by the State Power Authority in Schoharie County. The area included major portions of a deer wintering and spring concentration area some of which would be flooded leaving the deer with less winter and spring range. To compensate, 848 acres were designated as the Blenheim-Gilboa Wildlife Mitigation Area which would be managed for wildlife by the State Conservation Department, and the Power Authority financed the planting of white cedars on part of this tract as well as the installation of wire cylinders around them. In 1978 the author was engaged to evaluate the program and the results achieved from 1971 to 1979. This paper presents his findings.

BACKGROUND

Some 2,000 white cedars, purchased from commercial nurseries, had been planted on the Blenheim-Gilboa Wildlife Mitigation Area between 1971 and 1976. They were 8 to 10 years old, 2 to 4 feet high and 12 to 24 inches in diameter. Large nursery stock, instead of small 2- to 3-year-old seedlings, was used so as to advance by 5 to 8 years the time when the cedars would be large enough to warrant conclusions regarding the effectiveness of the wire cylinders.

The cylinders were made of welded wire fencing with 2 x 4-inch mesh, ranged in diameter between 1½ and 3 feet, and were 6 feet high. They

were supported by two or three studded T-iron posts (or ½-inch reinforcing rods) 7 feet long that were driven 2 feet into the ground. Soft iron wire was used to fasten the fencing to the posts. Earlier tests had shown that flexible hinge joint fencing was not sufficiently rigid to withstand the push pressure of foraging deer. Between 1976 and 1978, the alternate vertical wires of the fencing were cut out making a 4 x 4-inch mesh. Also, the height of the cylinders was lowered to 4, 4½ or 5 feet with the majority being made 5 feet high.

In 1979, 400 white cedars were planted that were 8 to 10 years old, 3 to 4 feet high and 18 to 24 inches in diameter. The cylinders used for these were made of 11 gauge welded wire with 4 x 4-inch mesh and were 34 inches in diameter by 5 feet high. They were supported by three posts like the ones used before. In this planting the cedars were planted 12 feet apart or 300 per acre, whereas previous plantings had been much farther apart.

PROCEDURE

The objectives of the study were to determine the amount of forage produced by and available to deer from cedars protected by wire cylinders, to estimate the degree to which that browse would augment the carrying capacity of the range, to determine the optimum distribution of such feeders[2] per unit of area, to appraise the structure and size of the cylinders and to evaluate the benefits of such protection in relation to the costs involved. Information was recorded seasonally and annually in 1978 and 1979.

Forage production was assessed by determining the amount of new foliage on the cedars each fall that would be available to deer despite the protecting cylinder. This was done by clipping and weighing such foliage for a sample of the feeders during September, October or November to simulate deer browsing. The quantity clipped was never so great as to reduce the evergreen quality of the remaining foliage and the next year's annual production. In 1978 five cedars were clipped around their entire circumference, while in 1979 two were clipped in this way and 16 others to the extent of the top and one quadrant on the side. The feeders chosen for sampling were not selected at random, all those where the foliage did not touch or extend outside the cylinder being excluded. For the ones chosen, spring observations during previous years had shown that the deer reached through the 4 x 4-inch mesh an average of 3 inches or over the top of the cylinder to feed on the new foliage, but they did not browse the 1½-year-old twigs. Since deer had had free access to the feeders prior to the time of clipping, all foliage extending through or over the top of the cylinder plus that inside it and within 3 inches of the wire must have been produced during the current growing season. Therefore this was the foliage clipped.

[2] Because the role of the cylinder was not only to protect the cedars but also to allow some browsing on them, the combination of cedar and cylinder was termed a feeder.

A white cedar feeder, showing protecting wire cylinder with 4 x 4-inch mesh. Note that cedar has been browsed on all sides and over the top by deer.

The material clipped from each cedar in the sample was bagged separately and the fresh weight (i.e., total minus bag weight) was recorded. It was then oven-dried at 50° C. for 48 hours, in some cases having been air-dried for a time first. A few samples lost more than 1 per cent of their fresh weight during the last 8 hours of drying and were dried for an additional 8 to 12 hours or until the weight decline was less than 1 per cent.

For each feeder sampled, the diameter (and circumference as a check) and height were measured to the nearest tenth of an inch, and from these measurements the areas in square feet of the side and top growing surfaces of the cedar were determined. In calculating these areas, 3 inches, representing the extent to which deer reached through the mesh to feed, were deducted from the radius in each case. Browse production was analyzed in terms of the area of growing surface.

The number of deer that the forage produced would support under winter conditions was estimated by comparing the energy value of the forage with the energy requirements of deer. Information was also recorded concerning the design of the cylinders, spacing of the feeders and cost.

FINDINGS

From the measurements of the cylinders at the feeders sampled, it was calculated that for a standard cylinder 5 feet high and 34 inches in diameter the growing surface on the sides of the cedar that would produce forage for deer averaged 36.65 square feet and that on the top averaged 4.28 square feet. These values were used for calculating forage production.

Assessment of the amount of forage produced entailed the possibility that the quantity of new foliage on the cedars differed in relation to exposure (i.e., north, east, south or west). Therefore, each of the cedars sampled in 1978 and two of those sampled in 1979 were divided into quadrants corresponding to these directions (Figure 1), and the foliage

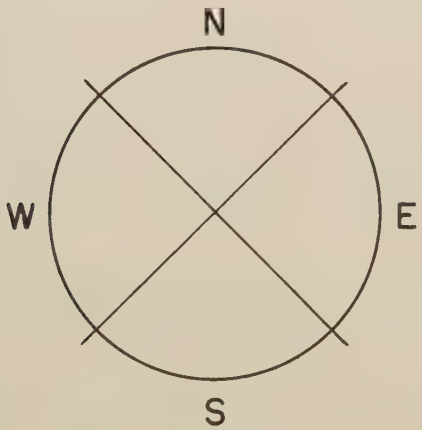


Figure 1. Orientation of quadrants used for assessing quantity of new foliage on cedars in relation to exposure. In order for south quadrant to represent the part of the cedar receiving maximum sunlight, the axes ran northeast-southwest etc. rather than north-south.

clipped in each quadrant was kept separate. The data, as oven-dried weight, are given in Table 1. Analysis by a one-way repeated measure design test (Steele and Torrie, 1960) showed no significant difference between quadrants ($P < 0.001$).

Also, in 1979, the new foliage was clipped from the top and one quadrant on the side of the cedars in 16 feeders. These were in sequence in a row, except that any where the foliage had not grown to or through the wire were skipped. The data, as oven-dried weight, are given in Table 2.

Table 1. Relative Production of New Foliage According to Quadrant on Five White Cedars Clipped in 1978 and Two Clipped in 1979

Year	Oven-dried weight (grams) per square foot of growing surface according to quadrant			
	North	East	South	West
1978*	7.13	6.59	1.58	5.35
	5.95	6.96	7.18	8.00
	3.22	3.08	6.99	4.83
	5.42	2.47	4.61	10.13
	10.06	7.78	9.23	9.76
1979§	20.46	27.81	21.59	29.94
	19.12	25.74	27.39	20.28

* Aggregate mean = 6.32; standard deviation = 2.52; standard error = 0.56.

§ Aggregate mean = 24.04; standard deviation = 4.15; standard error = 1.47.

Table 2. Production of New Foliage, As Oven-dried Weight (grams) Per Square Foot of Growing Surface, on Top and Side of 16 White Cedars Clipped in 1979

Top	Side (one quadrant)
35.90	29.94
24.28	27.38
20.47	28.46
32.37	24.28
17.36	16.13
12.73	10.28
17.45	6.01
20.91	7.91
31.28	16.23
24.18	1.09
7.54	14.30
17.93	11.45
32.37	2.73
19.51	9.76
20.38	6.78
14.78	12.72
Mean 21.84*	14.09§

* Standard deviation = 7.84; standard error = 1.96.

§ Standard deviation = 9.11; standard error = 2.28.

Mean production for the top and side was 21.84 grams and 14.09 grams, respectively. The difference was significant ($P < 0.01$) according to the t test ($t = 3.07$ with 15 degrees of freedom). Furthermore, production for the 16 quadrants was significantly different ($P < 0.001$) from that for the 20 quadrants clipped in 1978 ($t = 13.07$ with 34 degrees of freedom).

The data, in terms of mean production per square foot of growing surface, are summarized for the two years in Table 3. Production in 1978 was significantly lower ($P < 0.001$) than that in 1979. Although these records are the only ones available, they were used as factors to compute low and high production (Table 4).

The next step was to determine the degree to which this browse production would augment the carrying capacity of the area for deer. To assess the nutritional value of the clipped foliage, two samples of the oven-dried material were sent to the Wildlife Ecology Laboratory at Cornell Universi-

TABLE 3. COMPARATIVE PRODUCTION OF NEW FOLIAGE ON WHITE CEDARS CLIPPED IN 1978 AND 1979

Number of cedars clipped	Mean oven-dried weight per square foot of growing surface*			
	1978		1979	
	Grams	Ounces	Grams	Ounces
		Side		
5 (20 quadrants)	6.32 ± 2.52	0.22 ± 0.09	. .	. .
2 (8 quadrants)	. .	. .	24.04 ± 4.15	0.85 ± 0.15
16 (16 guadrants)	. .	. .	14.09 ± 9.11	0.50 ± 0.32
		Top		
16	. .	. .	21.84 ± 7.84	0.77 ± 0.28

* Plus or minus value represents standard deviation.

TABLE 4. CALCULATED LEVELS OF LOW AND HIGH PRODUCTION OF NEW WHITE CEDAR FOLIAGE FOR A STANDARD FEEDER

Part of cedar	Total growing surface (square feet)	Production (ounces)*			
		Low		High	
		Factor§	Total	Factor§	Total
Side	36.65	0.22	8.06	0.50†	18.33
Top	4.28	0.35‡	1.50	0.77	3.30
Total: ounces			9.56		21.63
pounds			0.60		1.35

* As oven-dried weight.

§ Mean weight per square foot of growing surface (from Table 3).

† To be conservative and because it was based on a larger sample, the value for the group of 16 cedars was used as the factor for the side production in 1979.

‡ Top production was not measured in 1978, but side production was 45 per cent of that in 1979. Therefore, it was assumed that top production in 1978 was 45 per cent of that in 1979, i.e., 9.83 grams or 0.35 ounce.

TABLE 5. ANALYAIS OF WHITE CEDAR FOLIAGE CLIPPED IN SEPTEMBER 1978

Sample	Percentage by weight							Digestibility coefficient
	Cell walls	Cell solubles	Acid detergent fiber	Lignin	Cutin	Hemicellulose	Cellulose	
1	59.70	40.30	46.42	18.14	11.24	13.29	16.34	59.24
2	55.15	44.85	42.24	15.28	15.58	12.91	16.69	60.80
Average	57.43	42.58	44.33	16.71	13.41	13.10	16.52	60.02

ty. The digestibility coefficient and other data (Table 5) were determined by a process described by Goering and VanSoest (1970) and used by Whittmore and Moen (1980). The standard values for gross energy (4,500 kilocalories per kilogram) and the metabolizable energy coefficient (0.86),

TABLE 6. ENERGY REQUIREMENTS OF MALE SEGMENT OF A HYPOTHETICAL POPULATION OF 100 DEER, HAVING THE COMPOSITION SHOWN IN TABLE 11, DURING THE WINTER ON THE STUDY AREA, AND THE DATA USED TO DERIVE THEM

Age group (years)	Julian day*	Average per deer						Deer days in each period	Hypothetical population	
		Age in days§	Calculated live weight (kilograms)†	Ingesta-free weight (kilograms)†	Multiple of baseline metabolism†	Kilocalories required per day	Dry weight of forage required per day (kilograms)‡		Kilograms of white cedar required per day (oven-dried weight)	Kilograms of white cedar required per 105-day winter season§§
½-1	1	215	39.03	35.19	2.19	2,214.91	0.95	420.0	400.63	
	16	230	35.90	32.39	2.06	1,957.82	0.84	420.0	354.13	
	31	245	32.46	29.10	1.94	1,710.65	0.74	420.0	309.42	
	46	260	29.10	26.29	1.82	1,479.15	0.64	420.0	267.55	
	61	275	26.22	23.71	1.72	1,293.67	0.56	420.0	234.00	
	76	290	24.14	21.84	1.65	1,166.87	0.50	420.0	211.06	
	91	305	23.08	20.89	1.60	1,094.39	0.47	420.0	197.95	1,974.74
1½-2	1	580	58.11	52.25	2.19	2,979.25	1.28	88.5	113.55	
	16	595	53.69	48.20	2.06	2,637.85	1.14	88.5	100.54	
	31	610	49.04	44.15	1.94	2,325.94	1.00	88.5	88.65	
	46	625	44.62	40.19	1.82	2,033.56	0.88	88.5	77.51	
	61	640	40.85	36.82	1.72	1,799.66	0.78	88.5	68.59	
	76	655	38.10	34.36	1.65	1,639.16	0.71	88.5	62.47	
	91	670	36.58	33.00	1.60	1,542.07	0.66	88.5	58.77	570.08
2½-3	1	945	70.87	63.63	2.19	3,453.73	1.49	19.5	29.00	
	16	960	65.98	59.27	2.06	3,080.29	1.33	19.5	25.87	
	31	975	60.88	54.72	1.94	2,732.18	1.18	19.5	22.94	
	46	990	56.05	50.41	1.82	2,410.22	1.04	19.5	20.24	
	61	1,005	51.94	46.74	1.72	2,152.25	0.93	19.5	18.07	
	76	1,020	48.92	44.04	1.65	1,974.55	0.85	19.5	16.58	
	91	1,035	47.22	42.52	1.60	1,864.93	0.80	19.5	15.66	148.36
3½-4	1	1,310	81.02	72.76	2.19	3,819.11	1.64	7.5	12.94	
	16	1,325	75.92	68.13	2.06	3,419.55	1.47	7.5	11.05	
	31	1,340	70.62	63.41	1.94	3,051.53	1.31	7.5	9.86	
	46	1,355	65.60	58.93	1.82	2,709.70	1.17	7.5	8.75	
	61	1,370	61.33	55.12	1.72	2,435.61	1.05	7.5	7.87	
	76	1,385	58.18	52.31	1.65	2,246.57	0.97	7.5	7.26	
	91	1,400	56.38	50.70	1.60	2,128.01	0.92	7.5	6.87	64.60
4½ & older	1	1,675	89.66	80.26	2.19	4,110.71	1.77	3.0	5.31	
	16	1,690	84.47	75.74	2.06	3,702.19	1.59	3.0	4.78	
	31	1,705	79.08	70.94	1.94	3,319.47	1.43	3.0	4.29	
	46	1,720	73.99	66.41	1.82	2,963.77	1.28	3.0	3.83	
	61	1,735	69.65	62.54	1.72	2,677.60	1.15	3.0	3.46	
	76	1,750	66.45	59.69	1.65	2,480.32	1.07	3.0	3.20	
	91	1,765	64.61	58.05	1.60	2,355.43	1.01	3.0	3.04	27.91
Total										2,785.69

* Cumulative day of year according to Julian calendar. The corresponding dates each year are: January 1, 16 and 31; February 15; March 2 and 17; and April 1.

§ Cumulative age based on a standard birth date of June 1.

† See text for definition or manner of derivation.

‡ For convenience, these values are given to two decimal points. However, in deriving the figures in the table that are based on them, 6-decimal values were used.

§§ Dates represent beginning of each 15-day period, so that the last period extends to April 15 making 105 days for the season.

TABLE 7. ENERGY REQUIREMENTS OF FEMALE SEGMENT OF A HYPOTHETICAL POPULATION OF 100 DEER, HAVING THE COMPOSITION SHOWN IN TABLE 11, DURING THE WINTER ON THE STUDY AREA, AND THE DATA USED TO DERIVE THEM

Age group (years)	Julian day*	Average per deer						Deer days in each period	Hypothetical population	
		Age in days§	Calculated live weight (kilograms)†	Ingesta-free weight (kilograms)†	Multiple of baseline metabolism†	Kilocalories required per day	Dry weight of forage required per day (kilograms)‡†		Kilograms of white cedar required per day (oven-dried weight)	Kilograms of white cedar required per 105-day winter season§§
½-1	1	215	35.57	32.09	2.21	2,085.78	0.90	408.0	366.49	
	16	230	33.32	30.08	2.07	1,861.13	0.80	408.0	327.02	
	31	245	30.65	27.68	1.93	1,630.35	0.70	408.0	286.47	
	46	260	27.91	25.23	1.80	1,418.43	0.61	408.0	249.23	
	61	275	25.51	23.07	1.71	1,260.03	0.54	408.0	221.40	
	76	290	23.77	21.51	1.64	1,146.63	0.49	408.0	201.47	
	91	305	22.90	20.73	1.61	1,094.90	0.47	408.0	192.39	1,844.47
1½-2	1	580	46.82	42.16	2.02	2,339.51	1.01	159.0	160.02	
	16	595	44.25	39.86	1.84	2,043.24	0.88	159.0	139.91	
	31	610	41.30	37.22	1.70	1,793.20	0.77	159.0	122.79	
	46	625	38.32	34.56	1.63	1,626.36	0.70	159.0	111.37	
	61	640	35.68	32.19	1.62	1,532.51	0.66	159.0	104.94	
	76	655	33.68	30.40	1.67	1,513.46	0.65	159.0	103.63	
	91	670	32.53	29.37	1.79	1,580.81	0.68	159.0	108.25	851.09
2½-3	1	945	52.35	47.10	1.95	2,454.13	1.06	99.0	104.63	
	16	960	49.75	44.78	1.77	2,144.79	0.92	99.0	91.44	
	31	975	46.78	42.13	1.66	1,921.54	0.83	99.0	81.78	
	46	990	43.78	39.44	1.61	1,773.69	0.76	99.0	75.62	
	61	1,005	41.11	37.05	1.63	1,713.47	0.74	99.0	73.05	
	76	1,020	39.07	35.23	1.72	1,741.05	0.75	99.0	74.23	
	91	1,035	37.86	34.15	1.87	1,849.19	0.80	99.0	78.84	578.59
3½-4	1	1,310	56.05	50.41	1.95	2,582.38	1.11	94.5	105.10	
	16	1,325	53.46	48.10	1.77	2,262.98	0.97	94.5	92.10	
	31	1,340	50.50	45.45	1.66	2,034.03	0.88	94.5	82.78	
	46	1,355	47.50	42.77	1.61	1,884.86	0.81	94.5	76.71	
	61	1,370	44.83	40.38	1.63	1,827.72	0.79	94.5	74.38	
	76	1,385	42.79	38.56	1.72	1,863.07	0.80	94.5	75.82	
	91	1,400	41.56	37.46	1.87	1,982.05	0.85	94.5	80.66	587.55
4½ & older	1	1,675	58.84	52.90	1.95	2,677.47	1.15	201.0	231.77	
	16	1,690	56.25	50.59	1.77	2,350.28	1.01	201.0	203.45	
	31	1,705	53.31	47.96	1.66	2,117.71	0.91	201.0	183.32	
	46	1,720	50.33	45.30	1.61	1,967.88	0.85	201.0	170.35	
	61	1,735	47.68	42.93	1.63	1,913.62	0.82	201.0	165.65	
	76	1,750	45.63	41.10	1.72	1,954.37	0.84	201.0	169.18	
	91	1,765	44.39	39.99	1.87	2,081.63	0.90	201.0	180.19	1,303.91
Total										5,165.61

* Cumulative day of year according to Julian calendar. The corresponding dates each year are: January 1, 16 and 31; February 15; March 2 and 17; and April 1.

§ Cumulative age based on a standard birth date of June 1.

† See text for definition or manner of derivation.

‡ For convenience, these values are given to two decimal points. However, in deriving the figures in the table that are based on them, 6-decimal values were used.

§§ Dates represent beginning of each 15-day period, so that the last period extends to April 15 making 105 days for the season.

described by Moen and Scholtz (1981), were used to derive the kilocalories of energy per kilogram of oven-dried white cedar as follows:

$$\text{kilocalories per kilogram} = \text{gross energy per kilogram} \times \text{digestibility coefficient} \times \text{metabolizable energy coefficient}$$

$$= 4{,}500 \times 0.60 \times 0.86$$

$$= 2{,}322$$

The energy requirements of deer were then determined for a hypothetical population of 100 animals having the composition shown in Table 11 during the winter on the range being studied. The critical period was considered to be from January 1 to April 15, and for each sex and age group the average weight at 15-day intervals was calculated. From these weights the corresponding values for kilocalories required per day were computed, and then the amount of white cedar browse needed to meet those requirements was calculated. These data are presented in Tables 6 and 7.

Values for live weight were derived by converting the dressed weights reported by Severinghaus (1979: Tables 7 and 11) to live weights according to the equation given by Severinghaus (1949). Since these data were in pounds, they were multiplied by 0.4536 to express them in kilograms. However, these records were for hunter-killed animals taken in late November after deer had begun to decline in weight. Therefore, it was necessary to adjust the weights upward to an estimated earlier maximum as a basis for curves that would indicate the annual weight decline during

Table 8. Calculation of Maximum and Minimum Weights For Each Age Group Used For Fitting Curves Depicting Patterns of Weight Change During the Winter

Age (years)	Mean dressed weight* (pounds)	Calculated live weight when taken		Calculated maximum and minimum live weights (kilograms)§	
		Pounds	Kilograms	Maximum†	Minimum
Male					
½ - 1	69.5	90.1	40.9	42.9	23.0
1½ - 2	105.4	135.7	61.6	64.6	37.0
2½ - 3	130.0	166.9	75.7	79.5	47.0
3½ - 4	158.3	202.8	92.0	96.6	56.0
4½ & older	161.7	207.1	93.9	98.6	64.0
Female					
½ - 1	57.2	74.5	33.8	34.5	23.0
1½ - 2	91.7	118.3	53.7	54.7	32.0
2½ - 3	97.4	125.5	56.9	58.1	38.0
3½ - 4	97.6	125.8	57.1	58.2	41.0
4½ & older	100.5	129.4	58.7	59.5	44.0

* When taken during November hunting season (Table 11, Severinghaus, 1979).

§ These data constitute those necessary for fitting curves that depict the change in weight during the winter for the different age groups.

† Early-fall weight (see text); factors used: 1.05 for males, 1.02 for females.

TABLE 9. DATA USED AND VALUES OF FACTORS FOR PLOTTING CURVES OF WEIGHT CHANGE

Item	Age group (years)					Factor		Correlation
	1/2 - 1	1 1/2 - 2	2 1/2 - 3	3 1/2 - 4	4 1/2+	*a*	*b*	(r^2)
Male (power curve: $Y = aX^b$								
Maximum weight								
Age in days *(X)**	150	515	880	1,245	1,610			
Weight in kilograms								
From data *(Y)*	42.9	64.6	79.5	96.6	98.6	6.83	0.36428	0.99
From regression ($\hat{Y}$)	42.4	66.4	80.8	91.6	100.6			
Minimum weight								
Age in days *(X)*§	320	685	1,050	1,415	1,780			
Weight in kilograms								
From data *(Y)*	23.0	37.0	47.0	56.0	64.0	0.75	0.59455	1.00
From regression ($\hat{Y}$)	23.2	36.5	47.0	56.1	64.3			
Female (logarithmic curve: $Y = a + b\ln X$)								
Maximum weight								
Age in days *(X)**	165	530	895	1,260	1,625			
Weight in kilograms								
From data *(Y)*	34.5	54.7	58.1	58.2	59.9	−19.48	11.09177	0.91
From regression ($\hat{Y}$)	37.2	50.1	55.9	59.7	62.5			
Minimum weight								
Age in days *(X)*§	320	685	1,050	1,415	1,780			
Weight in kilograms								
From data *(Y)*	23.0	32.0	38.0	41.0	44.0	−47.86	12.27527	1.00
From regression ($\hat{Y}$)	23.0	32.3	37.5	41.2	44.0			

* Represents Julian day 301 for males and 316 for females, annually, and age of deer is calculated as cumulative from a standard birth date of June 1.

§ Represents Julian day 106 each year for both sexes.

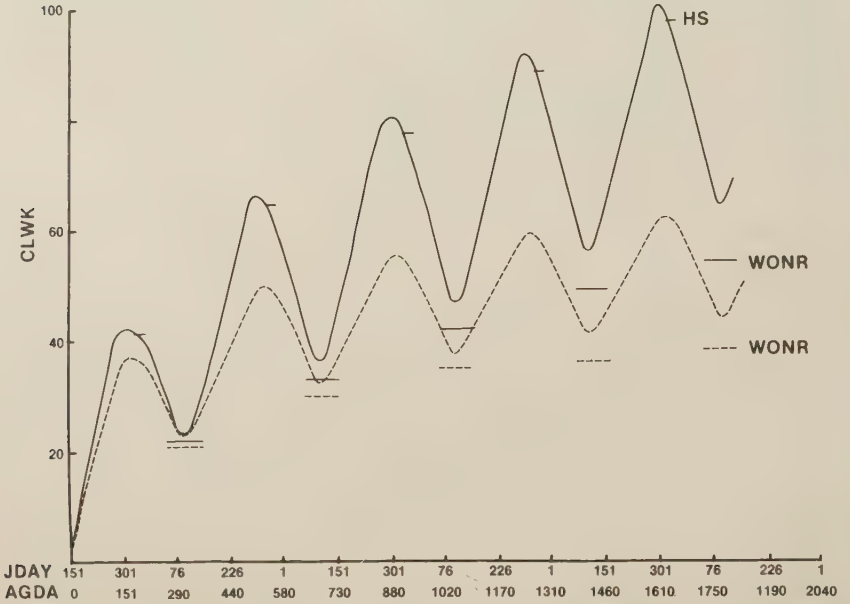


Figure 2. Curves depicting progressive trend in calculated live weight in kilograms (CLWK) for male (solid line) and female (dash line) deer in hypothetical population, with weight at time of hunting season (HS) and weight of no return (WONR) indicated. See footnotes to Tables 6 and 7 for definitions of "JDAY" and "AGDA".

the winter. The adjustments were made according to equations given by Moen (1973: Table A.5.4) and represented four weeks (to a peak on October 28) for males and two weeks (to a peak on November 12) for females. Similarly, minimum weights were needed for accurately plotting the bottom of these curves. The weight conversions are summarized in Table 8 together with the calculated maximum and minimum values used to derive equations for fitting the curves. The procedure was described by Moen and Severinghaus (1981) who found that power curves best fit the data for male deer, and logarithmic curves those for female deer. The data used and the values of the factors derived are given in Table 9. The curves are illustrated in Figure 2.

Ingesta-free weights were determined according to the equation given by Robbins et al. (1974)

$$\text{ingesta-free weight} = e^{(0.9928\ \ln x\ -\ 0.0771)}$$

in which

e = constant (= 2.718281828)

x = calculated live weight

The factor, multiple of baseline metabolism, represents the degree to which actual metabolism (i.e., ecological metabolism) exceeds resting metabolism as a result of activity and environmental conditions, and for females the presence of fetuses. The values were determined according to

methods described by Moen (1978). The number of fetuses per doe used were: 0.3 for females ½ to 1 year old; 1.6 for those 1½ to 2 years old; and 1.8 for those older than 2½ years.

In terms of ingesta-free weight (X) baseline metabolism equals $70X^{0.75}$ and ecological metabolism may be expressed as kilocalories per day (Moen, 1978). The number of kilocalories required per day may be derived from this value and the appropriate multiple of baseline metabolism (Y) by the following equation

$$\text{kilocalories required per day} = 70X^{0.75}Y$$

The dry weight of forage required per day was calculated by dividing the kilocalories required per day by the kilocalories per kilogram of oven-dried white cedar (i.e., 2, 322) as already determined.

The number of deer days of impact on the range were calculated for each age group and sex from data on the composition of the deer population in that area. The winter population on the study area in 1972-73 had been estimated by George Elliott of the Department of Environmental Conservation (unpublished data) to comprise 1,124 deer, including 316 male and 307 female fawns and 89 male and 415 female adults. However, an appraisal of the age distribution of the adults was needed. For this purpose, data for deer taken during the hunting season on Deer Management Unit 64[3] from 1974 to 1978 were used (Table 10). The percentages in this

TABLE 10. AVERAGE AGE DISTRIBUTION OF ADULT DEER TAKEN ON DEER MANAGEMENT UNIT 64 DURING THE HUNTING SEASON, 1974-1978*

Age (years)	Male		Female	
	Number	Per cent	Number	Per cent
1 1/2	474	73.8	84	28.6
2 1/2	110	17.1	52	17.7
3 1/2	44	6.9	51	17.3
4 1/2	11	1.7	48	16.3
5 1/2	1	0.2	25	8.5
6 1/2	2	0.3	14	4.8
7 1/2 - 10 1/2	0	0.0	20	6.8
Total	642	100.0	294	100.0

* Data largely from checking station records; those for males and females in no way represent sex ratios in the population.

table were applied to the adult segment of Elliott's estimate of the winter population on the study area to represent the composition of that population (Table 11), the percentage composition of which would also be that of the hypothetical population of 100. Therefore, for each age group and sex as shown in Tables 6 and 7, the number of deer days in each 15-day period equalled its percentage representation in the population times 100 times 15. For example, the value for male fawns during each period was derived as $0.28 \times 100 \times 15 = 420$.

[3] For deer management purposes, New York State has been divided into range units. Unit 64 includes the Blenheim-Gilboa Wildlife Mitigation Area.

Table 11. Composition of Estimated Winter Deer Population on the Study Area

Age (years)	Male		Female	
	Number	Per cent	Number	Per cent
1/2 - 1	316	28.0	307	27.2
1 1/2 - 2	66	5.9	119	10.6
2 1/2 - 3	15	1.3	74	6.6
3 1/2 - 4	6	0.5	71	6.3
4 1/2 & older	2	0.2	151	13.4
Total	405	35.9	722	64.1

Having determined the daily requirements of forage and the number of deer days, the total amount of white cedar browse (as oven-dried weight in kilograms) needed by each age group during each period was calculated by multiplying the two values. Finally, the totals for each age group, and for all ages combined, during the 105-day (January 1 to April 15) critical period were determined.

The daily energy requirements of deer may also be expressed in terms of kilocalories. The data in Table 12 indicate a decline in such requirements during the winter as the deer in each age group progressively lose weight, and they show that the energy requirements of the individual increase each year as the animal grows larger. They also indicate that, because of the presence of fetuses, females need a greater intake of energy late in winter than do males. These data, as applied to a hypothetical population of 100 deer, are summarized in Table 13 and indicate an average requirement of 48.92 kilocalories per deer per day. Since the average weight for deer of both sexes and all ages in the hypothetical population would be 35.63 kilograms (Table 14), this would represent an aggregate average daily requirement of 1,743.08 kilocalories.

Over the 105-day winter period the hypothetical population would require 7,951.30 kilograms of white cedar browse which would equal 17,529.61 pounds (oven-dried weight), or 1.667 pounds per deer day. The annual production of new white cedar foliage for a standard feeder, as oven-dried weight in pounds, ranged from a low of 0.60 in 1978 to a high of 1.35 in 1979 (Table 4). Thus a feeder would provide from 0.36 to 0.81 deer day of energy, and 300 feeders (the number of cedars planted per acre) would provide 107.34 to 242.85 deer days of energy or from 1.0 to 2.3 per cent of the total requirement of this population for 105 days. However, for 10 deer the proportion would be 10 to 23 per cent.

For a population of 10 deer per square mile, 5 acres of such feeders would provide from 50 to over 100 per cent of their total energy requirement during this period. On marginal range, especially, this would represent a significant augmentation of the carrying capacity.

The optimum density for the feeders is yet to be determined. In the present instance, the cedars were planted 12 feet apart or 300 per acre. Since the wire cylinders were 34 inches in diameter, the distance between feeders

Table 12. Energy Requirements, in Terms of Kilocalories Per Kilogram of Live Weight Per Day, of Individual White-tailed Deer According to Age and Sex

Age group (years)	Age (days)*	Male			Female		
		Kilocalories required per day§	Calculated live weight§ (kilograms)	Kilocalories required per kilogram per day	Kilocalories required per day§	Calculated live weight§ (kilograms)	Kilocalories required per kilogram per day
½ - 1	215	2,214.91	39.03	56.74	2,085.78	35.57	58.64
	335	1,145.61	24.34	47.07	1,163.85	23.86	48.78
	Average	1,464.44	28.60	51.20	1,422.21	27.47	51.78
1½ - 2	580	2,979.25	58.11	51.27	2,339.51	46.82	49.97
	700	1,580.18	37.49	42.15	1,932.04	32.89	58.74
	Average	2,007.13	43.88	45.75	1,787.80	37.55	47.61
2½ - 3	945	3,453.73	70.87	48.73	2,454.13	52.35	46.88
	1,065	1,898.72	47.97	39.58	2,302.25	38.04	60.52
	Average	2,383.44	55.19	43.18	1,988.30	42.92	46.33
3½ - 4	1,310	3,819.11	81.02	47.14	2,582.38	56.05	46.07
	1,430	2,159.97	57.04	37.87	2,462.06	41.65	59.14
	Average	2,673.59	64.63	41.37	2,115.32	46.62	45.37
4½ & older	1,675	4,110.53	89.66	45.85	2,677.47	58.84	45.50
	1,785	2,384.53	66.14	36.05	2,581.10	44.36	58.19
	Average	2,925.04	73.07	40.03	2,210.30	49.43	44.72

* For each age group, the figures represent the cumulative age of the deer on January 1 and May 1, based on a standard birth date of June 1.
§ From Tables 6 and 7.

Table 13. Average Energy Requirements, in Terms of Kilocalories Per Kilogram of Live Weight Per Day, For Hypothetical Population of 100 Deer

Age (years)	Kilocalories required per kilogram per day*	Hypothetical population	
		Relative size of age group§	Kilocalories required per day
Male			
1/2 - 1	51.20	28.0	1,433.6
1 1/2 - 2	45.75	5.9	269.9
2 1/2 - 3	43.18	1.3	56.1
3 1/2 - 4	41.37	0.5	20.7
4 1/2 & older	40.03	0.2	8.0
Sub-total	49.81	35.9	1,788.3
Female			
1/2 - 1	51.78	27.2	1,408.4
1 1/2 - 2	47.61	10.6	504.7
2 1/2 - 3	46.33	6.6	305.8
3 1/2 - 4	45.37	6.3	285.8
4 1/2 & older	44.72	13.4	599.3
Sub-total	48.42	64.1	3,104.0
Total	48.92	100.0	4,892.3

* Average values for each age group from Table 12.

§ Percentage composition of population from Table 11.

Table 14. Average Winter Weight of Deer on the Study Area

Age (years)	Male			Female		
	Number of deer*	Winter weight (kilograms)		Number of deer*	Winter weight (kilograms)	
		Average§	Total		Average§	Total
1/2	28.0	28.60	800.8	27.2	27.47	747.2
1 1/2 - 2	5.9	43.88	258.9	10.6	37.55	398.0
2 1/2 - 3	1.3	55.19	71.8	6.6	42.92	283.3
3 1/2 - 4	0.5	64.63	32.3	6.3	46.62	293.7
4 1/2 & older	0.2	73.07	14.6	13.4	49.43	662.4
Total	35.9	32.82†	1,178.4	64.1	37.20†	2,384.6

* In terms of percentage (Table 11) for hypothetical population of 100.

§ Data from Tables 6 and 7.

† Combined average weight of both sexes was 35.63 kilograms or 78.39 pounds.

was only 9 feet. There was no evidence that this produced a physical or psychological barrier to foraging deer. Based on the data in Table 4, the annual production of cedar browse was 179.25 to 405.56 pounds per acre. Observations indicated that this was fully used. It would be desirable to study the effects of closer spacing. However, the author believes that if the cylinders were only 6 or 7 feet apart deer would not completely use all the forage available.

The most efficient height for the cylinders depends on the usual accumulated depth of snow and the degree to which deer sink into the snow. It was found that a height of 5 feet above the level to which deer sink was necessary to give a cedar sufficient protection to maintain a growing top.

At the same time, deer browsing over the top of such cylinders removed most of the available forage and prevented the growth of a tree. Where the usual snow depth did not exceed a foot, the bottom of the cylinder was placed just off the ground. For greater snow depths, the cylinder bottom was raised accordingly to provide an effective 5-foot height during the winter. In areas where trials were begun prior to the present project, off-the-ground fencing of this sort has existed for more than 10 years without deer browsing under the wire and ruining the cedars.

The diameter is related to a deer's browsing reach over the top of the wire, and 34 inches was found best. A smaller cylinder did not provide sufficient growing space inside to assure survival of the cedar. A larger cylinder was too weak to withstand the push pressure of foraging deer, did not permit deer to forage across the top and sometimes was not filled with enough forage to extend through the mesh of the protecting wire.

It was also found that each cedar should have a single trunk. Multiple-trunk cedars produced too much wood inside the cylinder, and there was too little growing space between the trunks and the wire to assure either maximum forage production or survival of the cedars themselves.

Because of constantly rising prices, the cost of using white cedar feeders of this sort as a deer management measure can only be suggested. Eleven cylinders can be cut from one roll of 60-inch wire fencing, and two men can construct four or five an hour. At 1978-79 prices, this would represent about $6.50 each. The 7-foot studded T-iron post used to support each cylinder cost about $5.50. Thus the total cost of construction and installation was about $12.00 each. Assuming a situation where young cedars (about a foot high) can be dug from natural stands and transplanted, a cost of $5.00 each may be added, making a total of $17.00 per feeder. At an estimated life of 20 years, the average cost per year would be about 85¢.

On this basis, the cost of the forage produced by a standard feeder, i.e., 1.35 to 0.60 pounds per year (Table 4), would be $0.63 to $1.42 per pound. To meet the average daily requirement of 1.67 pounds (oven-dried weight) of white cedar browse per deer if only cedar were eaten, the cost would vary from $1.05 in a year of high forage production to $2.37 in a year of low production. In terms of a 105-day critical winter period, as considered in the present study, the corresponding cost of providing that amount of white cedar forage by this method would vary, roughly, from $110 to $250 per deer. For 10 deer, this would represent some 1,300 to 3,000 feeders, or 4 to 10 acres at the rate of 300 per acre. Thus, in a year of low production 5 acres of feeders, at a pro-rated cost of $255 per acre, would supply about half the energy requirement of a population of 10 deer per square mile on the winter range.

DISCUSSION

There are very few published reports that analyze production and cost in

relation to the carrying capacity of the range, with respect to providing winter forage for deer, as was done in this study. However, some contain data that may be used for comparison.

Davenport (1939) found that deer needed 1.98 pounds (dry weight) of white cedar per hundredweight per day. In the present study, where deer averaged 78.39 pounds (Table 14), the corresponding requirement during the winter was 2.13 pounds (oven-dried weight).

Ryel (1953) found that, in the area between 2 and 7 feet above the ground, white cedars produced a maximum of about 0.42 pound of browse (fresh weight). Aldous (1952) clipped white cedars 7 feet tall annually for seven years. The average production of browse per tree per year (fresh weight) was 0.38 pound where 50 per cent of the annual growth had been clipped and 0.39 pound where 25 per cent had been clipped. As oven-dried weight (conversion factor = 0.4698), these values would be 0.20, 0.18 and 0.18 pound, respectively. For the wire-protected cedars in the present study, production was 0.60 to 1.35 pound or three to seven times that of unprotected cedars of the same size. Also, the cedars in these feeders will not become overbrowsed in a few years, and neither will the deer population have to be held at 10-15 per square mile on the winter range to prevent this first-preference forage from being killed out by overbrowsing.

At 300 per acre, the feeders produced from 180 to 405 pounds (oven-dried weight) of white cedar forage per acre annually. Potvin and Huot (1979) studied browse production by deciduous species on an area in southern Quebec west of Sherbrooke and partly within the Mont Orford Provincial Park. Five blocks were clear cut, and forage production during the succeeding three years averaged 38.3, 63.2, 59.6 and 55.2 pounds (oven-dried weight) per acre. Peak production among the blocks ranged from 134 to less than 62.3 pounds and averaged 89 pounds. Production of white cedar by the feeders in the present study was two to five times the high production of the deciduous species. Also, while deer use of the deciduous browse was only 50 per cent the first year after cutting and 70 per cent during the second and third years, virtually 100 per cent of the white cedar available at the feeders was eaten. The deciduous species involved were red maple (40 per cent) and, in lesser proportions, trembling aspen, large-toothed aspen, pin cherry, chokecherry, black cherry, beaked hazelnut, white birch and sugar maple. Another factor is that white cedar has a 60 per cent digestibility by deer, while values for the deciduous species are lower: red maple (57 per cent), aspen (61 per cent), pin cherry (40 per cent), beaked hazelnut (49 per cent), black cherry (37 per cent), white birch (56 per cent) and sugar maple (46 per cent) according to Whittemore and Moen (personal correspondence, 1980). Considering production, use and digestibility, the energy value deer derive from wire-protected white cedars may be four to 12 times that from deciduous forage produced by natural reproduction following clear cutting.

Browse production from the white cedar feeders was also four to 12 times that of an uncut woodlot or forest. In such habitat, as reported by several authors (Patton and McGinnes, 1964; Pase and Hurd, 1958; McGinnes, 1949; Thompson, 1962) as well as observed by the present author (unpublished data), it averaged less than 30 pounds per acre (oven-dried weight) and ranged from less than 10 to about 100 pounds. Again, the digestibility of the species involved was less than that of white cedar.

A further consideration with respect to naturally growing forage is the duration of high browse production following clear cutting. The study by Potvin and Huot (1979) showed that production reached its peak during the second season and decreased slowly thereafter, the browse being above the reach of deer after the sixth year. They cited other work ". . . on the practical duration of such treatments: Cromer and Smith (1968) mentioned 8-10 years, Patton and McGinnes (1964) 5 years and Vallee et al., (1976) 5 to 15 years". The white cedar feeders have an effective life of at least 20 years, and their annual production of browse is continuous within a low-high range rather than progressively decreasing.

The present study has shown that the white cedar feeders described can furnish deer browse on a sustained yield basis. The data have also shown that, at a density of 300 per acre, 5 acres of such feeders can supply 50 per cent or more of the energy requirement of 10 deer during the critical winter period. Such supplemental forage can increase the carrying capacity of the range significantly for deer populations where existing winter food supplies are inadequate. The cost of constructing and installing these feeders has also been indicated. However, there are other factors that must be considered in deciding whether an intensive forage-production program of this sort is justifiable. First, ways and means must exist whereby all surplus deer from year to year can be harvested. Second, the summer forage must be sufficient to support any additional deer that may be enabled to survive the winter. Third, the presence of such additional deer must be compatible with man's other uses of the land. Only when these conditions are met is such intensive forage production justifiable.

LITERATURE CITED

ALDOUS, SHALER E. 1941. Deer management suggestions for northern white cedar types. Jour. Wildl. Mgt. 5(1):90-94.

_____ 1952. Deer browse clipping study in the Lake States region. Jour. Wildl. Mgt. 16(4):401-409.

CROMER, J. I., AND H. C. SMITH. 1968. Sufficient deer browse produced by a wide range of cutting practices. Trans. Northeast Fish and Wildl. Conf. 25:25-35.

DAVENPORT, L. A. 1939. Results of deer feeding experiments at Cusino, Michigan. Trans. N. Am. Wildl. Conf. 4:268-274.

FOX, WILLIAM F. 1896. Report of superintendent of forests on the Adirondack deer. In: First Annual Rept. New York Fish, Game and Forest Comm.:159-204.

GOERING, H. K., AND P. J. VANSOEST. 1970. Forage fiber analyses (apparatus, reagents, procedures and some applications). Agric. Handbook 379, U.S. Dept. Agric.

McGinnes, B. S. 1949. The effect of forestry cutting practices on the production of deer browse in the Virginia pine *(Pinus virginiana)* type. M.S. thesis, Penn. State College Library.

Moen, Aaron N. 1973. Wildlife Ecology: An analytical approach. W. H. Freeman and Co., San Francisco.

_____ _____ 1978. Seasonal changes in heart rates, activity, metabolism and forage intake of white-tailed deer. Jour. Wildl. Mgt. 42(4):715-738.

Moen, Aaron N., and Susan Scholtz. 1981. Nomographic estimation of forage intake of white-tailed deer. Jour. Range Mgt. 34(1):74-76.

Moen, Aaron N., and C. W. Severinghaus. 1981. The annual weight cycle and survival of white-tailed deer in New York. N.Y. Fish and Game Jour. 28(2):163-177.

Pase, C. P., and R. M. Hurd. 1958. Understory vegetation as related to basal area, crown cover and litter produce by immature ponderosa pine stands in the Black Hills. Proc. Soc. Am. Foresters Meeting 1957:156-158.

Patton, D. R., and B. S. McGinnes. 1964. Deer browse relative to age and intensity of timber harvest. Jour. Wildl. Mgt. 28(3):458-463.

Potvin, Francois, and Jean Huot. 1979. Deer browse production in small cutovers in southern Quebec. Wildl. Soc. Bull. 7(4):247-252.

Robbins, C. T., A. N. Moen and J. T. Reid. 1974. Body composition of white-tailed deer. Jour. Animal Sci. 38(4):871-876.

Ryel, Lawrence A. 1953. Effects of forest age and growth on the availability of forage for deer in white cedar swamps. M.S. thesis, Mich. State Coll. Library.

Severinghaus, C. W. 1949. The live weight-dressed weight and live-weight-edible meat relationship in deer. N.Y.S. Conservationist 4(2):26.

_____ 1979. Weights of white-tailed deer in relation to range conditions in New York. N.Y. Fish and Game Jour. 26(2):162-187.

Spiker, C. J. 1933. Some late winter and early spring observations of white-tailed deer of the Adirondacks. Roos. Wildl. Bull. 6(2):327-335.

Steele, R. D. G., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Thompson, R. L. 1962. An investigation of some techniques for measuring availability of oak mast and deer browse. M.S. thesis, Virginia Polytech. Inst. Library.

Vallee, J., R. Couture and R. Joyal. 1976. Etude de la regeneration apres coupe des assences composant la diete alimentaire de l'original. Phytoprotection 57:155-164.

Whittemore, S., and A. N. Moen. 1980. Composition and in vitor digestibilities of various summer foods of white-tailed deer. Can. Jour. Animal Sci. 60:189-192.

DIET COMPOSITION AND DIEL FEEDING PERIODICITY OF SOME FISHES IN THE ST. LAWRENCE RIVER

Neil H. Ringler
Associate Professor, School of Biology, Chemistry and Ecology
State University of New York College of Environmental Science and Forestry

James H. Johnson
Research Assistant, School of Biology, Chemistry and Ecology
State University of New York College of Environmental Science and Forestry[1]

ABSTRACT

The diets of 901 fish representing nine species, collected in the St. Lawrence River at Cape Vincent and Massena from July to October in 1976, were examined. Fish were gill netted at 4-hour intervals at depths of 5 and 10 meters. Amphipods appeared to be a major prey of many adult fish (e.g., yellow perch, rock bass, alewife, white sucker and brown bullhead). Cladocerans were the most important zooplankton taken by planktivorous fishes (i.e., alewife and gizzard shad). Invertebrate eggs represented nearly 67 per cent of the diet of yellow perch in July. Feeding periodicity of yellow perch and rock bass was similar to that reported for a lake in the Province of Ontario. However, diel patterns of yellow perch and alewife at a depth of 5 meters appeared to differ from those at 10 meters.

An understanding of fish feeding ecology is necessary in order to properly assess the effect of environmental modifications on fish populations. While adult fish may adapt to the immediate effects of changes in shelter, streamflow, temperature, sediment load or water chemistry, prey populations are generally more sensitive. Benthic invertebrates in particular are less mobile and more habitat-specific in their distribution than fishes, and their population levels may respond more rapidly to the same changes. For example, hydropsychid caddisflies emerged 2 weeks earlier than normal in response to a 1° C. increase in water temperature in the Columbia River (Coutant, 1967). Long-term alterations in fish populations may occur as a result of such changes in the food supply, since the rate of growth and ultimate size of fish depend directly on the quantity and composition of the prey consumed (see Ishiwata, 1969). Further, for many populations, rates of survival and fecundity are closely correlated with body size. Any change in growth rate may, therefore, influence reproduction rates directly (via survival) or indirectly (via fecundity) as noted by Weatherley (1972).

The results of investigations by Keast (1966, 1968) suggest that fish size, rather than age, is most important in bringing on changes in diet during development. Over the short term, Keast and Welsh (1968), Elliot (1970) and Zweiacker and Summerfelt (1974) have documented daily or diel periodicity in feeding activity and food consumption for fish populations. Such periodicity reflects either an activity pattern characteristic of certain

[1] Present affiliation: NezPerce Tribe of Idaho, P.O. Box 365, Lapwai, Idaho 83540.

fish species or responses to changes in prey abundance. Seasonal changes in food consumption rates have been documented in many populations and may be related to changes in fish distribution and/or feeding activity (see Baumann and Kitchell, 1974), as well as to fluctuations in prey availability.

Feeding ecology seems to have been studied much less in large rivers than in lakes or small streams. Thus, except for descriptive investigations by Sibley and Rimsky-Korsakoff (1930), practically no work has been published dealing directly with the feeding ecology of fishes in the St. Lawrence River. Because of possible changes in connection with extending the winter navigation season on the river (Geis, 1977), a study of the diets of fish there was undertaken during the summer of 1976 in cooperation with the Department of Environmental Conservation (Cape Vincent Fisheries Station). The objectives were to identify and rank prey organisms eaten by representative fishes of the St. Lawrence River and to examine the variation in diet composition for these species in relation to date, depth and sampling site.

METHODS AND MATERIALS

The St. Lawrence River flows for more than 1,200 kilometers from eastern Lake Ontario to the Gulf of St. Lawrence and in its first 160 kilometers borders Jefferson and St. Lawrence Counties of New York. The fish reported in the study were collected in the upper part of this section at Cape Vincent and in the lower part near Massena (Figure 1). Two gill nets, 61 meters long by 2.4 meters deep (consisting of eight 7.6-meter panels of 3.8 x 15.2-centimeter stretched mesh) were set at each site, one at a depth of 5 meters and the other at 10 meters. Examination of the nets at 4-hour intervals provided data on feeding periodicity. Each fish collected was weighed while still intact. Most were slit abdominally immediately upon being taken from the net and preserved in 10 per cent formalin, but for a few exceptionally large specimens the stomach was removed and placed directly in the preservative after the fish had been measured. In the laboratory, the samples were sorted by species, size, water depth, site and time of capture. The stomach was removed and its contents was stored in 70 per cent ethyl alcohol prior to microscopic (40×) examination. For fishes (e.g., Catostomidae) in which no clear distinction exists between the stomach and intestine, the anterior third of the gut was examined.

Most prey were identified to family, except for fish and aquatic insects where generic or specific designation was usually feasible. Samples of each prey taxon (by size) were dried for 24 hours at 105° C. and weighed on a Mettler balance. Mean weights of these samples were used to estimate the weight of each prey component from its numerical representation in the stomach contents. Prey items were grouped for analysis within appropriate taxonomic categories (family or order), and diet composition was ex-

Figure 1. Section of the St. Lawrence River bordering New York showing location of Cape Vincent and Massena where fish were collected.

pressed as percentage by number and by weight. These percentages in turn were used to rank the foods from most to least important. For fish species caught in adequate numbers, the total dry weight of each stomach contents was calculated, and the corresponding weight per gram of fish was used to examine major diel patterns of food consumption.

RESULTS AND DISCUSSION

The diets of 901 fish representing nine species were examined. Yellow perch *(Perca flavescens)*, rock bass *(Ambloplites rupestris)* and alewife *(Alosa pseudoharengus)*, in decreasing order of abundance, dominated the catch. The other species collected in sufficient numbers for analysis were smallmouth bass *(Micropterus dolomieui)*, pumpkinseed *(Lepomis gibbosus)*, white perch *(Morone americana)*, gizzard shad *(Dorosoma cepedianum)*, brown bullhead *(Ictalurus nebulosus)* and white sucker *(Catostomus commersoni)*. Of the total, 823 specimens were collected at Cape Vincent and 78 at Massena. Apparent differences in diets between the two sites may reflect, in part, differences in sample size.

DIET COMPOSITION

Data for the fish collected at Cape Vincent are given first (Table 1). For

Table 1. Composition in Percentage By Dry Weight of Stomach Contents of Yellow Perch, Rock Bass, Alewives and Smallmouth Bass Collected At Cape Vincent From July to October in 1976*

Taxon	July	August	September	October
Yellow perch				
Nematoda	t	t	. .	. .
Cladocera	t	. .	t	. .
Ostracoda	t	. .	t	t
Planariidae	. .	. .	. .	0.1
Hirudinea	0.1	0.4	0.3	0.7
Hydracarina	t	t	10.1	. .
Isopoda	7.5	2.1	. .	17.8
Amphipoda	16.5	76.8	72.4	67.3
Leptoceridae	0.5	3.2	0.7	1.7
Psychomyiidae	. .	. .	t	t
Chironomidae	0.4	1.0	1.1	0.6
Gastropoda	4.2	4.0	8.0	8.0
Sphaeriidae	. .	0.6	0.5	1.2
Unionidae	4.1	. .	1.9	1.6
Fish	. .	11.9	0.1	1.0
Invertebrate eggs	66.7	. .	4.9	. .
Diptera (aerial)	t	. .	. .	. .
Lepidoptera	. .	t	. .	. .
Total	100.0	100.0	100.0	100.0
Number of fish	198	143	101	65
Total length (millimeters)				
Minimum	132	129	122	133
Maximum	258	251	237	230
Rock bass				
Nematoda	0.1	t	. .	. .
Ostracoda	. .	t	. .	. .
Hirudinea	0.5	. .	0.6	1.3
Hydracarina	. .	t	. .	. .
Decapoda	10.8	0.8	. .	. .
Isopoda	2.8	2.3	0.1	2.7
Amphipoda	76.3	81.4	87.6	87.7
Hydroptilidae	. .	. .	t	. .
Lepidostomatidae	. .	. .	t	. .
Leptoceridae	3.7	5.4	0.5	3.1
Chironomidae	t	0.1	t	0.1
Gastropoda	1.3	9.4	10.5	4.6
Pelecypoda	1.0	0.6	0.3	0.5
Fish	3.5	. .	0.4	. .
Fish eggs	t	. .	. .	. .
Total	100.0	100.0	100.0	100.0
Number of fish	40	24	62	25
Total length (millimeters)				
Minimum	130	136	95	135
Maximum	241	217	205	233
Alewife				
Nematoda	. .	. .	. .	0.2
Cladocera	53.5	. .	. .	31.3
Copepoda	9.7	. .	. .	17.1
Ostracoda	0.5	. .	. .	. .
Hydracarina	. .	. .	. .	0.1
Amphipoda	27.8	. .	. .	49.0
Leptoceridae	6.7	. .	. .	. .
Chironomidae	1.8	. .	. .	0.6
Fish	. .	. .	. .	1.7
Total	100.0	. .	. .	100.0

TABLE 1. *(continued)*

Taxon	July	August	September	October
Number of fish	67	0	0	23
Total length (millimeters)				
Minimum	131	. .	. .	140
Maximum	181	. .	. .	192
Smallmouth bass				
Copepoda (parasitic)	. .	0.3	. .	. .
Amphipoda	0.1	0.2	. .	. .
Leptoceridae	. .	1.1	. .	. .
Chironomidae	. .	t	. .	. .
Alewife	76.8	81.6	. .	. .
Fish (unidentified)	23.1	16.8	. .	. .
Total	100.0	100.0	. .	. .
Number of fish	12	24	0	0
Total length (millimeters)				
Minimum	208	200	. .	. .
Maximum	432	366	. .	. .

* t = trace (< 0.05 per cent).

yellow perch the chief food during July was invertebrate eggs which made up nearly 67 per cent of the diet by weight. Amphipods ranked second during July and became the major item thereafter. Isopods and gastropods comprised much of the rest of the diet throughout the season. Aquatic insects amounted to only 1-5 per cent, while zooplankton (ostracods and cladocerans) were minimal in both weight and numbers.

Rock bass fed principally on amphipods, which increased somewhat in importance through the season. Invertebrate eggs were not found. Decapods amounted to more than 10 per cent of the diet in July, but were virtually absent thereafter when gastropods ranked second. Leptocerid larvae and pupae contributed up to 5 per cent (in August), but chrionomid larvae and pupae made up less than 1 per cent. Except for a small number of ostracods taken in August, zooplankton was not eaten by these rock bass.

Alewives fed heavily on cladocerans, amphipods and copepods during July, with a small contribution by ostracods and the larvae and pupae of leptocerids and chironomids. Unfortunately, no alewives were captured during August and September, but the October sample provided some interesting results. Amphipods became the most important food, followed by cladocerans and copepods. Ostracods disappeared from the diet, whereas fish, nematodes and water mites appeared in small quantities.

Smallmouth bass were not well represented in the samples, probably because of an ability to avoid gill nets. The results are included because of the importance of this species to the St. Lawrence sport fishery. In July, the diet was almost entirely fish, the remainder being amphipods. Similarly, fish predominated in August, although amphipods, parasitic copepods *(Argulus* sp.), leptocerid larvae and chironomid pupae appeared in small

Table 2. Composition in Percentage By Dry Weight of Stomach Contents of Pumpkinseed, Gizzard Shad and White Suckers Collected At Cape Vincent From July to October in 1976*

Taxon	Pumpkinseed	Gizzard shad	White sucker
Cladocera	. .	63.2	. .
Copepoda	. .	1.0	. .
Ostracoda	. .	2.3	t
Amphipoda	5.8	2.4	63.8
Leptoceridae	. .	. .	0.6
Chironomidae	0.2	. .	0.1
Gastropoda	93.7	25.5	24.4
Pelecypoda	0.3	5.6	11.1
Total	100.0	100.0	100.0
Number of fish	19	8	12
Total length (millimeters)			
Minimum	137	149	376
Maximum	231	416	577

* t = trace (< 0.05 per cent).

quantities. No prey were found in the few specimens taken during September and October.

Data for species caught in relatively small numbers at Cape Vincent are summarized in Table 2 for the period of July to October. Pumpkinseed sunfish were taken only in September. Gastropods (principally Hydrobiidae) made up nearly 94 per cent of their food, with amphipods contributing most of the remainder. Their diet thus appears to have been complementary to that of rock bass during this period. Gizzard shad fed chiefly on cladocerans, but gastropods (almost exclusively Valvatidae) made up a large portion of their diet while use of pelecypods, amphipods and copepods was minimal. White suckers fed principally on amphipods, gastropods and pelecypods, but small numbers of chironomid and leptocerid larvae, and ostracods, also were taken. Although data for the four months are lumped, in general it appears that the diet composition of white suckers was very similar to that of yellow perch and rock bass, the only important difference being the greater use of pelecypods by the suckers.

All fish caught at Massena were treated as a single sample for the period of July to October (Table 3). Yellow perch fed predominantly on fish, amphipods, chironomids, leptocerids and invertebrate eggs. Compared with the data for Cape Vincent, the large contribution of fish, appearance of Hymenoptera, smaller contribution of amphipods and absence of isopods suggest a real difference in the food of yellow perch at Massena. A more detailed comparison does not seem warranted by the data.

Rock bass at Massena fed largely on fish, decapods, leptocerids and amphipods. Gastropods and isopods were absent. Though limited, these data also suggest a difference in comparison with those for Cape Vincent where amphipods were of major importance and fish were a minor component of the diet.

TABLE 3. COMPOSITION IN PERCENTAGE BY DRY WEIGHT OF STOMACH CONTENTS OF FISH COLLECTED AT MASSENA FROM JULY TO OCTOBER IN 1976*

Taxon	Yellow perch	Rock bass	Alewife	Smallmouth bass	White perch	Brown bullhead
Nematoda	t	. .	. .	. .	. .	0.2
Cladocera	t	t	2.3	. .	0.1	1.0
Copepoda	t	. .	2.0	. .	0.1	0.6
Ostracoda	t	. .	2.2	. .	t	0.7
Hydracarina	1.7	0.1	1.9	. .	. .	0.1
Decapoda	. .	28.0	. .	. .	. .	. .
Amphipoda	20.2	6.5	11.5	. .	4.4	49.6
Brachycentridae	t	. .	. .	. .	. .	. .
Hydroptilidae	t	0.2	. .	. .	. .	. .
Leptoceridae	11.6	26.6	13.3	. .	. .	2.1
Psychomyiidae	. .	0.6	. .	. .	. .	. .
Chironomidae	18.7	. .	56.7	. .	44.4	34.3
Ceratopogonidae	. .	. .	7.9	. .	. .	. .
Gastropoda	1.6	. .	. .	. .	. .	. .
Pelecypoda	0.4	. .	. .	. .	. .	10.5
Alewife	. .	. .	. .	59.8	. .	. .
Fish (unidentified)	41.1	38.0	1.9	40.2	51.0	. .
Invertebrate eggs	4.5	. .	. .	. .	. .	. .
Coleoptera (terrestrial)	. .	. .	. .	. .	. .	0.9
Hymenoptera	0.1	. .	0.3	. .	. .	. .
Lepidoptera	0.1	. .	. .	. .	. .	. .
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of fish	39	5	6	4	17	7
Total length (millimeters)						
Minimum	125	122	107	275	116	143
Maximum	258	196	177	383	259	224

* t = trace (< 0.05 per cent).

For the alewife, chironomids and leptocerids apparently were more important at Massena than at Cape Vincent where cladocerans and amphipods comprised most of the diet. Because of the large difference in sample size, however, this may not have reflected a real difference between the two populations.

The smallmouth bass had fed entirely on fish. The diet of white perch consisted of fish, chironomids, amphipods and small quantities of zooplankton. Brown bullheads fed on amphipods, chironomids, pelecypods, leptocerids and small quantities of other prey including zooplankton, water mites and terrestrial beetles, indicating that they are generalized feeders.

DIET COMPOSITION VERSUS WATER DEPTH

Diet composition in relation to depth of capture was examined for yellow perch (July and September) and alewives (July) at Cape Vincent (Table 4). Differences between the 5-meter and 10-meter depths were relatively minor for yellow perch. Alewives, on the other hand, ate predominantly cladocerans at 5 meters and amphipods at 10 meters.

Table 4. Composition in Percentage By Dry Weight of Stomach Contents of Yellow Perch and Alewives Collected At Cape Vincent During July and September in 1976, According to Water Depth

Taxon	July		September	
	5 meters	10 meters	5 meters	10 meters
	Yellow perch			
Nematoda	t	. .	. .	. .
Hydracarina	t	t	. .	. .
Cladocera	. .	t	t	. .
Ostracoda	. .	t	t	t
Hirudinea	. .	t	0.1	0.3
Isopoda	. .	11.7	11.9	7.6
Amphipoda	8.9	20.7	70.6	75.8
Leptoceridae	1.2	0.1	0.3	1.1
Chironomidae	0.7	0.3	2.2	0.1
Gastropoda	6.8	2.5	14.6	1.2
Pelecypoda	6.7	2.5	0.3	2.6
Invertebrate eggs	75.7	62.2	. .	11.2
Fish (unidentified)	. .	. .	. .	0.1
Total	100.0	100.0	100.0	100.0
Number of fish	93	105	58	43
Total length (millimeters)				
Minimum	146	132	123	122
Maximum	252	258	207	237
	Alewife			
Cladocera	66.2	18.2	. .	. .
Copepoda	7.1	16.2	. .	. .
Ostracoda	0.4	0.5	. .	. .
Amphipoda	15.8	58.8	. .	. .
Leptoceridae	7.9	3.5	. .	. .
Chironomidae	2.7	2.8	. .	. .
Total	100.0	100.0	. .	. .
Number of fish	38	29	0	0
Total length (millimeters)				
Minimum	133	131	. .	. .
Maximum	179	181	. .	. .

Feeding Periodicity

Diel trends in feeding were examined for yellow perch, rock bass and alewives. Because during some intervals only a few individuals of each species were collected, the data for July, August and September were combined. This increased the sample size for each 4-hour interval, and it provided an indication of the mean summer feeding periodicity for these fish. The results indicated that the timing of peaks and troughs changed little from month to month (Figure 2) and that the mean summer periodicity was not an artificial result of combining the data.

Yellow perch exhibited marked differences in periodicity between the two depths. At 5 meters, feeding activity peaked at 1000 hours and then declined sharply until late evening. However, at 10 meters the peak occurred between 1600 and 2000 hours. Unlike yellow perch, rock bass showed similar patterns of feeding at both depths. Peak feeding occurred during late evening and early morning (2000 to 0600 hours). Differences between depths were exhibited by the alewives, but their pattern of food consump-

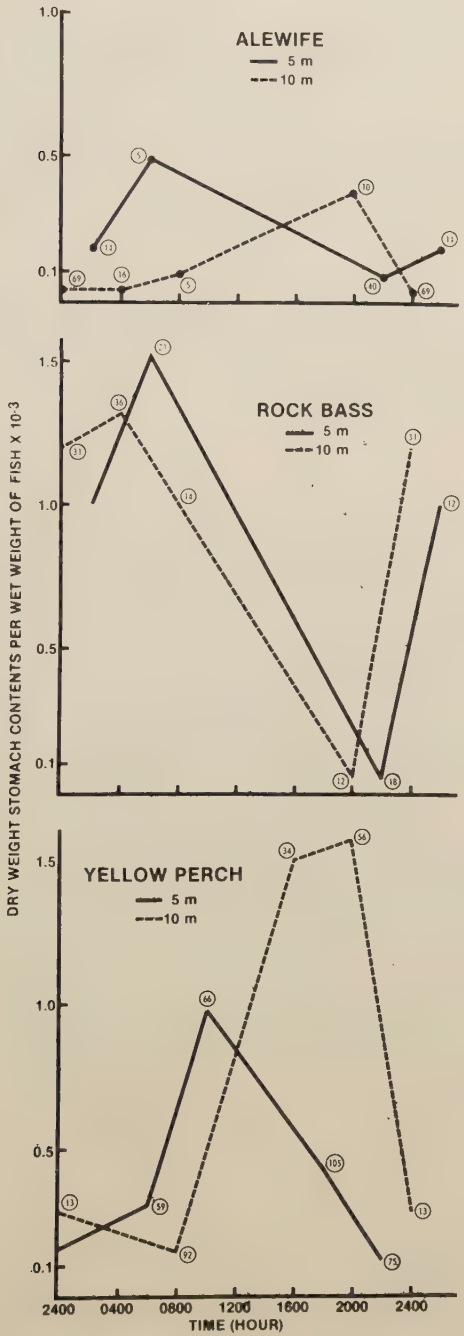


Figure 2. Feeding periodicity of yellow perch, rock bass and alewives at depths of 5 and 10 meters in the St. Lawrence River at Cape Vincent during the summer of 1976. Circled figures represent number of specimens.

tion was less distinct than that of yellow perch or rock bass. At 5 meters, feeding activity increased after 2200 hours and reached a peak at 0600 hours. At 10 meters, on the other hand, peak feeding by alewives occurred at 2000 hours.

The patterns of feeding periodicity of yellow perch (at 10 meters) and rock bass were roughly comparable to those reported by Keast and Welsh (1968) for Lake Opinicon in Ontario. At depths of 0.6 to 4.6 meters (2 to 15 feet) in Lake Opinicon, peak feeding of yellow perch occurred at 2000 hours, with a lesser peak at 1000 hours. At 10 meters in the St. Lawrence River it occurred between 1600 and 2000 hours, after feeding activity had increased sharply between 0800 and 1600 hours. Rock bass in Lake Opinicon fed most heavily from 2100 to 0800 hours which was similar to the findings of the present study, i.e., 2000 to 0600 hours at depths of both 5 and 10 meters.

LITERATURE CITED

Coutant, C. C. 1967. Effect of Temperature on the development rate of bottom organisms. In: Biological Effects of Thermal Discharges. Am. Rep. Pacific N.W. Lab., U.S. Atomic Energy Comm., Div. Biol. Medicine:11-12.

Elliot, J. M. 1970. Diel changes in invertebrate drift and the food of trout *(Salmo trutta* L.). Jour. Fish. Biol. 2:161-165.

Geis, J. W. [Ed.]. 1977. Preliminary report: biological characteristics of the St. Lawrence River. New York State Univ. College Environ. Sci. and Forestry at Syracuse.

Ishiwata, N. 1969. Ecological studies on the feeding of fishes—VIII: frequency of feeding and growth. Bull. Jap. Soc. Sci. Fish. 35(10):985-990.

Keast, A. 1966. Trophic interrelationships in the fish fauna of a small stream. Publ. 15, Great Lakes Res. Div., Univ. Mich.:51-79

_____ 1968. Feeding biology of the black crappie. *Pomoxis nigromaculatus.* Jour. Fish. Res. Bd. Canada 25(2):285-297.

Keast, A., and L. Welsh. 1968. Daily feeding periodicities, food uptake rates, and dietary changes with hour of day in some fishes. Jour. Fish. Res. Bd. Canada 25(6):1133-1144.

Sibley, C. K., and U. Rimsky-Korsakoff. 1930. Food of certain fishes in the watershed. In: A Biological Survey of the St. Lawrence Watershed. N.Y.S. Cons. Dept.:109-120.

Weatherley, A. H. 1972. Growth and Ecology of Fish Populations. Academic Press, New York.

Zweiacker, P. L., and R. C. Summerfelt. 1974. Seasonal variation in food and diel periodicity in feeding of northern largemouth bass, *Micropterus s. salmoides* (Lacepede), in an Oklahoma reservoir. Proc. Conf. Southeastern Assoc. Game and Fish Comm. 27:579-591.

BASIS FOR USING SELECTED SEX RATIOS IN THE HARVEST FOR DERIVING QUOTAS FOR HARVESTING ANTLERLESS DEER

Nathaniel R. Dickinson Supervising Wildlife Biologist
New York State Department of Environmental Conservation, Wildlife Resources Center, Delmar, N.Y. 12054

ABSTRACT

A method of deriving quotas for harvesting antlerless deer, by using selected sex ratios in the harvest depending on whether it is desirable to stabilize, increase or decrease the population, is described. It basically requires only knowledge of the harvest of adult males and eliminates the need for elaborate population modeling. Examples are given to illustrate the effects of different harvest ratios on a hypothetical population embodying an initial 100 adult males.

New York has developed a sophisticated and successful management program for white-tailed deer. A reliable means of aging deer (Severinghaus, 1949) provided a basis for calculating population composition. Reproductive studies, such as those of Cheatum and Severinghaus (1950), provided information for assessing recruitment. Analysis of data on population age composition (Maguire and Severinghaus, 1954) showed that, for both adult males and adult females, the age composition of the legal harvest may be considered representative of that of the corresponding wild population. Therefore, such data may be used for determining the rates at which the various age groups in the population are being removed. Also, Severinghaus and Maguire (1955) found that age composition data can be used to calculate sex ratios among adult deer. More recent studies, such as that of Hesselton and Jackson (1974) dealing with reproductive rates, have provided refinements for analyzing deer population dynamics.

Since the early 1960's Department biologists have used selected ratios of adult females to adult males in the legal harvest for deriving quotas for harvesting antlerless deer. Experience during that time has shown the appropriate ratio to apply to produce a desired result, i.e., to stabilize, increase or decrease a population. Moreover, a simple but effective method has been developed that basically requires only knowledge of the harvest of adult males. This shortcut eliminates the need for annual involvement in elaborate population modeling.

Questions are often raised regarding the basis for using such ratios in this way. Why are certain ratios used? Why does the effect on the deer population of applying a certain ratio vary from area to area, and why do the ratios that work in actual population management differ from those that theoretically produce the desired result? This paper discusses these questions and presents hypothetical examples to illustrate what happens when harvests ratios are changed. It is hoped that this approach will

engender confidence in the applicability of a technique that can greatly simplify deer population management.

Analyses of population data show that a ratio of adult females to adult males in the legal harvest that is equal to the corresponding sex ratio for deer at the time they are recruited into the adult (1 year olds and older) population will produce stabilization regardless of the number or percentage of adult males removed or the ratio of fawns to adult females in the harvest or the rate of reproduction. This relationship is demonstrated in the following tables in which the sex ratios used are believed to be those that best illustrate the points being made. To simplify explanation, the sex ratio among fawns and that among yearlings prior to the hunting season are considered to be the same, although in reality this may seldom happen.

Tables 1 to 5 all assume an initial number of 100 adult males and a hunting season harvest of 80 per cent of these animals. For fawns the harvest is assumed to be 0.6 per adult female taken. Fawn production is based on reproductive rates of 0.3 per 1-year-old female, 1.4 per 2-year-old female and 1.9 per older female, with the age distribution of the breeding females from year to year in each table being based on the corresponding harvest rate for adult females. Each table illustrates an assumed sex ratio for fawns and, based on the known dynamics of a deer population having the given sex ratio, reproductive rates and harvest rate for fawns, the proportion of adult females that must be removed each year to maintain a stable population is determined. Then the initial number of adult females in each case is calculated from the equation (based on Severinghaus and Maguire, 1955)

$$\text{adult females per adult male} = \frac{M}{F} \div X$$

in which

M = hunting season harvest rate for adult males

F = hunting season harvest rate for adult females

X = number of male fawns per female fawn

Each table is carried through the late summer of the fourth year. In these tables, for simplicity, all mortality is attributed to legal hunting.

Table 1 shows the dynamics of a population with a sex ratio among fawns, as well as among yearlings at the time of recruitment as adults, of 125 males to 100 females. If the foregoing relationship between the sex ratio in the legal harvest and the population trend holds true, a harvest ratio of 0.8 adult female per adult male (i.e., 100/125) will be associated with a stable population. Starting with an initial late-summer population of 100 males, and assuming a harvest rate of 40 per cent for females, the corresponding number of 160 females is calculated from the equation

TABLE 1. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 125 MALES TO 100 FEMALES, SHOWING THAT IT WILL BE HELD AT A STABLE LEVEL BY A HARVEST RATIO OF 0.8 ADULT FEMALE PER ADULT MALE

Item	Adult		Fawn			Origin of fawns according to age group of adult females§		
	Male	Female	Total	Male	Female	1 year	2 years	Older
Year 1								
Late-summer population*	100	160	182			64 (19)	38 (53)	58 (110)
Hunting season harvest†	80	64	38					
Post-hunting population	20	96	144	80	64			
Reproductive increment	80	64						
Net adult population	100	160	xxx	xxx	xxx	xxx	xxx	xxx
Year 2								
Late-summer population	100	160	182			64 (19)	38 (53)	58 (110)
Hunting season harvest†	80	64	38					
Post-hunting population	20	96	144	80	64			
Reproductive increment	80	64						
Net adult population	100	160	xxx	xxx	xxx	xxx	xxx	xxx
Year 3								
Late-summer population	100	160	182			64 (19)	38 (53)	58 (110)
Hunting season harvest†	80	64	38					
Post-hunting population	20	96	144	80	64			
Reproductive increment	80	64						
Net adult population	100	160	xxx	xxx	xxx	xxx	xxx	xxx
Year 4								
Late-summer population	100	160	182			64 (19)	38 (53)	58 (110)

* Initial late-summer population derived as explained in text, the number of females being based on a removal rate of 40 per cent.

§ See text for basis of calculation; figures in parentheses represent number of fawns produced.

† Harvest of adult females calculated by applying 0.8 ratio to harvest of adult males.

TABLE 2. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 111 MALES TO 100 FEMALES, SHOWING THAT IT WILL BE HELD AT A STABLE LEVEL BY A HARVEST RATIO OF 0.9 ADULT FEMALE PER ADULT MALE

Item	Adult		Fawn			Origin of fawns according to age group of adult females§		
	Male	Female	Total	Male	Female	1 year	2 years	Older
Year 1								
Late-summer population*	100	176	198			72 (22)	43 (60)	61 (116)
Hunting season harvest†	80	72	43					
Post-hunting population	20	104	155	82	73			
Reproductive increment	82	73						
Net adult population	102	177	xxx	xxx	xxx	xxx	xxx	xxx
Year 2								
Late-summer population	102	177	198			73 (22)	43 (60)	61 (116)
Hunting season harvest†	82	74	44					
Post-hunting population	20	103	154	81	73			
Reproductive increment	81	73						
Net adult population	101	176	xxx	xxx	xxx	xxx	xxx	xxx
Year 3								
Late-summer population	101	176	198			72 (22)	43 (60)	61 (116)
Hunting season harvest†	81	73	44					
Post-hunting population	20	103	154	81	73			
Reproductive increment	81	73						
Net adult population	101	176	xxx	xxx	xxx	xxx	xxx	xxx
Year 4								
Late-summer population	101	176	198			72 (22)	43 (60)	61 (116)

* Initial late-summer population derived as explained in text, the number of females being based on a removal rate of 41 per cent.

§ See text for basis of calculation; figures in parentheses represent number of fawns produced.

† Harvest of adult females calculated by applying 0.9 ratio to harvest of adult males.

TABLE 3. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 100 MALES TO 100 FEMALES, SHOWING THAT IT WILL BE HELD AT A STABLE LEVEL BY A HARVEST RATIO OF 1.0 ADULT FEMALE PER ADULT MALE

Item	Adult		Fawn			Origin of fawns according to age group of adult females§		
	Male	Female	Total	Male	Female	1 year	2 years	Older
Year 1								
Late-summer population*	100	190	210			80 (24)	46 (64)	64 (122)
Hunting season harvest†	80	80	48					
Post-hunting population	20	110	162	81	81			
Reproductive increment	81	81						
Net adult population	101	191	xxx	xxx	xxx	xxx	xxx	xxx
Year 2								
Late-summer population	101	191	212			80 (24)	47 (66)	64 (122)
Hunting season harvest†	81	81	49					
Post-hunting population	20	110	163	82	81			
Reproductive increment	82	81						
Net adult population	102	191	212		xxx	xxx	xxx	xxx
Year 3								
Late-summer population	102	191	212			80 (24)	47 (66)	64 (122)
Hunting season harvest†	82	82	49					
Post-hunting population	20	109	163	81	82			
Reproductive increment	81	82						
Net adult population	101	191	xxx	xxx	xxx	xxx	xxx	xxx
Year 4								
Late-summer population	101	191	212			80 (24)	47 (66)	64 (122)

* Initial late-summer population derived as explained in text, the number of females being based on a removal rate of 42 per cent.

§ See text for basis of calculation; figures in parentheses represent number of fawns produced.

† Harvest of adult females calculated by applying 1.0 ratio to harvest of adult males.

already given. Then these females are separated into three age groups on the basis of the harvest rate, i.e., if 40 per cent of them are removed each year, then that proportion (64) of the total are 1 year olds and the same proportion (38) of those remaining are 2 year olds, while the other 58 are older. The number of fawns produced (182) is calculated according to the reproductive rate for each age group.

The hunting season harvest of 80 adult males represents the assumed 80 per cent for this segment of the population, and from it the harvest of adult females (64) is calculated according to the assumed ratio of 0.8 female per male. Then the harvest of fawns (38) is determined from the assumed ratio of 0.6 fawn per adult female taken.

Subtracting the harvest from the late-summer population leaves the post-hunting population. The remaining fawns (144) are assigned sexes according to the given 125 male to 100 female ratio, and these (80 and 64) are added to the residual adults as the reproductive increment.

The same steps are repeated through the late summer of the fourth year. The late-summer population remains the same from year to year because, with a sex ratio among fawns of 125 males to 100 females and a harvest ratio of 0.8 adult female per adult male, the annual reproductive increment equals the hunting season loss.

Table 2 illustrates what happens in a hypothetical population with a sex ratio among fawns of 111 males to 100 females and a harvest rate of 41 per cent for adult females. In this case stabilization is achieved by harvesting 0.9 adult female per adult male which is equivalent to the sex ratio among the fawns. The calculation procedure is the same as that used in Table 1. The minor deviations in the late-summer population from year to year result from rounding certain figures.

Table 3 illustrates a population with a sex ratio of one to one among the fawns and a harvest ratio of 42 per cent for adult females. Here, stabilization results from taking 1.0 adult female per adult male.

In Table 4 the initial late-summer population, and all the other factors, are exactly the same as in Table 1, except that the harvest rate for adult females has been increased from 0.8 to 0.9 per adult male taken. The result is a gradually declining population. After three hunting seasons, the late-summer population is 18 per cent lower for males and 23 per cent lower for females. With respect to the adult females, the proportion of the late-summer population that is harvested amounts to 45, 47 and 48 per cent in the three years, respectively. It is recognized that this is not consistent with the harvest rate of 40 per cent for females as used in determining the initial population and fawn production. Actually, the greater rate of removal for adult females would mean proportionally more in the younger age groups and lower fawn production, as well as fewer adult females in the initial population, so that the population decline would be even faster. Nevertheless, the data demonstrate that, under the basic conditions

TABLE 4. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 125 MALES TO 100 FEMALES, SHOWING THAT A DECREASE WILL RESULT FROM A HARVEST RATIO OF 0.9 ADULT FEMALE PER ADULT MALE

Item	Adult		Fawn			Origin of fawns according to age group of adult females§		
	Male	Female	Total	Male	Female	1 year	2 years	Older
			Year 1					
Late-summer population*	100	160	182			64 (19)	38 (53)	58 (110)
Hunting season harvest†	80	72	43					
Post-hunting population	20	88	139	77	62			
Reproductive increment	77	62						
Net adult population	97	150	xxx	xxx	xxx	xxx	xxx	xxx
			Year 2					
Late-summer population	97	150	171			60 (18)	36 (50)	54 (103)
Hunting season harvest†	78	70	42					
Post-hunting population	19	80	129	72	57			
Reproductive increment	72	57						
Net adult population	91	137	xxx	xxx	xxx	xxx	xxx	xxx
			Year 3					
Late-summer population	91	137	156			55 (17)	33 (46)	49 (93)
Hunting season harvest†	73	66	40					
Post-hunting population	18	71	116	64	52			
Reproductive increment	64	52						
Net adult population	82	123	xxx	xxx	xxx	xxx	xxx	xxx
			Year 4					
Late-summer population	82	123	141			49 (15)	30 (42)	44 (84)

* Initial late-summer population derived as explained in text, the number of females being based on a removal rate of 40 per cent.

§ See text for basis of calculation; figures in parentheses represent number of fawns produced.

† Harvest of adult females calculated by applying 0.9 ratio to harvest of adult males.

TABLE 5. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 125 MALES TO 100 FEMALES, SHOWING THAT AN INCREASE WILL RESULT FROM A HARVEST RATIO OF 0.7 ADULT FEMALE PER ADULT MALE

Item	Adult		Fawn			Origin of fawns according to age group of adult females§		
	Male	Female	Total	Male	Female	1 year	2 years	Older
Year 1								
Late-summer population*	100	160	182			64 (19)	38 (53)	58 (110)
Hunting season harvest†	80	56	34					
Post-hunting population	20	104	148	82	66			
Reproductive increment	82	66						
Net adult population	102	170	xxx	xxx	xxx	xxx	xxx	xxx
Year 2								
Late-summer population	102	170	193			68 (20)	41 (57)	61 (116)
Hunting season harvest†	82	57	34					
Post-hunting population	20	113	159	88	71			
Reproductive increment	88	71						
Net adult population	108	184	xxx	xxx	xxx	xxx	xxx	xxx
Year 3								
Late-summer population	108	184	209			74 (22)	44 (62)	66 (125)
Hunting season harvest†	86	60	36					
Post-hunting population	22	124	173	96	77			
Reproductive increment	96	77						
Net adult population	118	201	xxx	xxx	xxx	xxx	xxx	xxx
Year 4								
Late-summer population	118	201	230			80 (24)	48 (67)	73 (139)

* Initial late-summer population derived as explained in text, the number of females being based on a removal rate of 40 per cent.

§ See text for basis of calculation; figures in parentheses represent number of fawns produced.

† Harvest of adult females calculated by applying 0.7 ratio to harvest of adult males.

postulated, taking 0.9 adult female per adult male will result in overharvesting (Table 4) whereas taking 0.8 adult female per adult male will maintain a stable population (Table 1).

Table 5 is the counterpart of Table 4 and illustrates the effect of decreasing the harvest rate for adult females from 0.8 to 0.7 per adult male taken. The result is underharvest and a gradually increasing population in which the proportion of the adult females present in late summer that are harvested amounts to 35, 34 and 33 per cent in the three years, respectively. There is a similar inconsistency between these figures and the 40 per cent harvest rate used in determining the initial population and fawn production, so that the actual rate of increase would be greater.

These five tables have dealt with deer populations where all the mortality was assumed to be in the form of legal harvest. Tables 6 and 7 illustrate situations where the initial late-summer population, the sex ratio among fawns and the harvest rate for adult males are all the same as those in

TABLE 6. DYNAMICS OF A DEER POPULATION HAVING A SEX RATIO AMONG FAWNS OF 125 MALES TO 100 FEMALES, SHOWING THAT IT WILL BE HELD AT A STABLE LEVEL BY A HARVEST RATIO OF 0.4 ADULT FEMALE PER ADULT MALE WHEN HALF THE TOTAL MORTALITY OF ADULT FEMALES IS DUE TO CAUSES OTHER THAN LEGAL HUNTING

Item	Adult		Fawn§		
	Male	Female	Total	Male	Female
Year 1					
Late-summer population*	100	160	182		
Hunting season harvest†	80	32	38		
Post-hunting population	20	128	144	80	64
Other mortality	0	32			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 2					
Late-summer population	100	160	182		
Hunting season harvest†	80	32	38		
Post-hunting population	20	128	144	80	64
Other mortality	0	32			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 3					
Late-summer population	100	160	182		
Hunting season harvest†	80	32	38		
Post-hunting population	20	128	144	80	64
Other mortality	0	32			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 4					
Late-summer population	100	160	182		

* Initial late-summer population derived as in Table 1.

§ Initial number and reproduction calculated as in Table 1; harvest assumed to be 1.2 per adult female taken.

† Harvest of adult females calculated by applying 0.4 ratio to harvest of adult males.

Table 1, but where the removal of adult females, although the total proportion is the same, is due in part to causes other than legal hunting. Here again it must be emphasized that these are hypothetical cases that are simplified for purposes of illustration. In reality, if adult females are being lost to such sources, so also would be fawns and adult males.

In Table 6 the total removal rate of 40 per cent for adult females represents a 20 per cent loss (32) from legal hunting and an equal loss due to other causes, all of the latter being assumed to occur after the fawns are weaned. Also the mortality ratio of 0.6 fawn per adult female lost as used in the preceding tables is considered to apply to all adult females lost, but in this table the fawn mortality (38) is based entirely on the hunting season harvest and a ratio of 1.2 is used. Since the harvest of adult males is 80 (as in the preceding tables), the loss from other causes amounts to 0.4 adult female per adult male taken, and an equivalent harvest by legal hunting is

Table 7. Dynamics of a Deer Population Having a Sex Ratio Among Fawns of 125 Males to 100 Females, Showing That It Will Be Held At a Stable Level By a Harvest Ratio of 0.6 Adult Female Per Adult Male When the Mortality of Adult Females Consists of 30 Per Cent From Legal Hunting and 10 Per Cent From Other Causes

Item	Adult		Fawn§		
	Male	Female	Total	Male	Female
Year 1					
Late-summer population*	100	160	182		
Hunting season harvest†	80	48	38		
Post-hunting population	20	112	144	80	64
Other mortality	0	16			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 2					
Late-summer population	100	160	182		
Hunting season harvest†	80	48	38		
Post-hunting population	20	112	144	80	64
Other mortality	0	16			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 3					
Late-summer population	100	160	182		
Hunting season harvest†	80	48	38		
Post-hunting population	20	112	144	80	64
Other mortality	0	16			
Remainder	20	96			
Reproductive increment	80	64			
Net adult population	100	160	xxx	xxx	xxx
Year 4					
Late-summer population	100	160	182		

* Initial late-summer population derived as in Table 1.

§ Initial number and reproduction calculated as in Table 1; harvest assumed to be 0.8 per adult female taken.

† Harvest of adult females calculated by applying 0.6 ratio to harvest of adult males.

required for the aggregate removal of adult females to be the 0.8 per adult male that has been shown (Table 1) to produce a stable population when the sex ratio among fawns is 125 males to 100 females. Thus, when mortality among adult females from causes other than legal hunting that is disproportionate to such losses among adult males is recognized, the proportion of females in the annual increment cannot be used directly as the harvest ratio for maintaining a stable population.

Table 7 is a variation of Table 6 in which the total removal rate of 40 per cent for adult females represents a 30 per cent loss (48) from legal hunting and a 10 per cent loss (16) due to other causes. Again fawn mortality is calculated from the hunting season harvest and the ratio becomes 0.8 per adult female taken. In this case, the loss of adult females from other causes amounts to 0.2 per adult male harvested, so that a harvest rate of 0.6 adult female per adult male taken is required for the aggregate removal to be the 0.8 per male needed for population stability. This also shows that, when non-random losses from causes other than legal hunting are recognized, adjustments must be made in the harvest rate as derived from the sex ratio of the annual increment.

In these two examples, the losses from causes other than legal hunting are restricted to adult females. If, on the other hand, they applied to all segments of the population at the same rate, there would be no change in the sex ratio among adults at the time of the hunting season and the proportion of females in the annual increment would represent the harvest rate of adult females required to maintain a stable population.

In Table 1 it was shown, for a deer population where the removal rate for adult males was 80 per cent and that for adult females was 40 per cent, that if the starting point was 100 adult males there would be 160 adult females and a harvest rate of 0.8 adult female per adult male would maintain a stable population. If the removal of the adult males comprised 60 per cent from legal hunting and 20 per cent from other causes, but the numerical legal harvest remained 80, then the starting population of adult males would be 134 and the corresponding number of adult females would be 213. The total number removed would be 107 and 85, respectively, three-quarters of which in each case would represent the legal harvest so that this would still be 80 adult males and 64 adult females and a harvest ratio of 0.8 female per male would still be applicable. The relationships involved are shown in Table 8. The difference is that the population is actually larger than that calculated from the legal harvest alone. Nevertheless, if a manager does not have a measure of other losses, calculations based on a starting population of 100 adult males are valid. Although it would be desirable for the legal harvest to be the only form of mortality, other losses, so long as they are random, do not affect the usefulness of the ratio of adult females to adult males in the legal harvest as a means of deriving quotas for harvesting antlerless deer.

Table 8. Dynamics of a Deer Population Subject to a Total Mortality of 80 Per Cent Among Adult Males and 40 Per Cent Among Adult Females, Of Which Three-quarters Is Due to Legal Hunting and One-quarter to Other Causes, When the Number of Males Legally Taken Is 80

Item	Adult	
	Male	Female
Late-summer population	134*	213§
Hunting season harvest	80	64†
Post-hunting population	54	149
Other mortality	27	21
Remainder	27	128

* Derived from assumption that legal harvest of 80 adult males represents three-quarters of total mortality of 80 per cent.

§ Derived from the late-summer population of 134 adult males by the same procedure used in Table 1.

† Represents 0.8 female per male.

Likewise, changes in reproductive rates or in the ratio of fawns per adult female harvested do not necessitate changing the ratio of females to males to be used for calculation. Rather, the allowable proportion of the adult females that should be removed from the population is changed. The lower the reproductive rate or the higher the ratio of fawns to be removed, the lower the proportion of females to be removed.

Two tables are given to further explain how using the sex ratio among fawns as the harvest ratio for adults will produce population stabilization. For a population having an initial component of 100 adult males and a sex ratio among the fawns of 125 males to 100 females, Table 9 shows the variation in the number of adult males and adult females that will result from using the same harvest ratio of 0.8 female per male (i.e., equivalent to the ratio among the fawns) but changing the proportion of the males present that are taken. As this proportion increases, so also must the number of females taken. Seemingly, this would lead to an overharvest of females. Table 10 shows why this does not happen. Two values for the proportion of females removed are illustrated. As the number of adult males removed from the population increases, there is a corresponding increase in the proportion of females in the sex ratio and in the number of adult females in the late-summer population. This compensatory relationship allows for a greater harvest of adult females without an overharvest. The number of females removed, as derived in each of these tables, is the same.

A 40 per cent removal of adult females is considered about average. A 30 per cent removal would be associated with somewhat lower reproductive rates than those assumed in preceding tables and/or a higher ratio of fawns to adult females in the harvest. Either way, a higher population of adult females or a lower removal rate would be necessary to maintain a stable population. The difference in the proportion of females removed produces different sex ratios and higher late-summer populations of females. It is apparent that the same harvest ratio of females per male may be used regardless of the proportion of adult females removed.

TABLE 9. BASED ON A LATE-SUMMER POPULATION OF 100 ADULT MALE DEER, CALCULATED NUMBER OF ADULT FEMALES TO BE HARVESTED TO MAINTAIN A STABLE POPULATION, USING THE SAME HARVEST RATIO, AT DIFFERENT LEVELS IN THE PROPORTION OF MALES REMOVED

Adult males			Adult females to be harvested	
Late-summer population	Removed			
	Per cent	Number	Rate*	Number
100	40	40	0.8	32
100	50	50	0.8	40
100	60	60	0.8	48
100	70	70	0.8	56
100	80	80	0.8	64

* Number of females per male for a sex ratio among the fawns of 125 males to 100 females.

Following are three examples of the actual application of sex ratios among fawns to derive quotas for harvesting antlerless deer. In New York, the holder of a deer management permit is entitled to take one deer of either sex in addition to whatever other deer he is licensed to take. These permits are issued for deer management units when it is felt that the taking of such deer is needed to achieve proper balance between the deer population and its range. Each management unit has an "established buck take index" which represents the average harvest of bucks per square mile that will be produced when the deer population is at the desired level in terms of its compatibility with other land uses and the carrying capacity of the range. In each of these examples the index was 3-4. The harvest of bucks per square mile on these units from 1976 to 1980 was as follows

	1976	1977	1978	1979	1980
Unit A	3.7	4.5	4.3	4.0	4.6
Unit B	5.1	5.9	6.2	7.1	6.8
Unit C	3.1	3.4	2.9	2.4	2.4

On Unit A, the buck take was brought down to the top of the index in 1979, but it increased again in 1980 and a reduction in the population was called for. Past experience on this area indicated that a harvest ratio of 0.6 adult female per adult male stabilized population levels signifying substantial losses of adult females from causes other than legal hunting. Accordingly, a ratio of 0.8 was selected for 1981 to reduce the population, and the buck take of 556 for the unit in 1980 was multiplied by it to give 445 as the desired harvest of adult females in 1981. Since only 60 per cent of the deer taken under the management permits are adult females, the quota of antlerless deer to be taken was 742, and because only half the permit holders are successful the number of permits to be issued in 1981 was 1,484.

On Unit B, the population had been allowed to remain at a level where the buck take was annually well above the index and drastic reduction in

Table 10. For the Same Initial Population of Adult Males and the Same Levels in the Proportion of Males Removed As in Table 9, Calculated Number of Adult Females To Be Harvested When the Proportion Removed Remains the Same

Adult males			Adult female per adult male in population*	Adult females		
Late-summer population	Removed			Late-summer population§	To be harvested	
	Per cent	Number			Per cent	Number
40 per cent removal of adult females						
100	40	40	0.8	80	40	32
100	50	50	1.0	100	40	40
100	60	60	1.2	120	40	48
100	70	70	1.4	140	40	56
100	80	80	1.6	160	40	64
30 per cent removal of adult females						
100	40	40	1.06	106	30	32
100	50	50	1.33	133	30	40
100	60	60	1.60	160	30	48
100	70	70	1.87	187	30	56
100	80	80	2.13	213	30	64

* Derived from equation based on Severinghaus and Maguire (1955), for a sex ratio of 125 males to 100 females among the fawns (see text).

§ In relation to 100 males according to ratio of females to males.

the population was called for. Because experience indicated that a harvest ratio of 0.7 adult female per adult male maintained a stable population, a ratio of 1.1 was selected. The buck take in 1980 was 1,601 which, multiplied by this ratio, gave 1,761 as the desired harvest of adult females. Based on the same conversion factors used for Unit A, this represented 2,935 antlerless deer to be taken under permit and 5,870 permits to be issued.

On Unit C, the population had produced a harvest below the index for three consecutive years, and experience showed that a harvest ratio of slightly less than 0.6 adult female per adult male resulted in a stable population. In order to increase the population, a ratio of 0.3 was selected. The buck take in 1980 was 389 which, multiplied by this ratio, gave 117 as the desired harvest of adult females in 1981 which would require taking 195 antlerless deer. In this case a 40 per cent success rate for permit holders was used and gave 488 as the number of permits to be issued.

The foregoing description of the use of the proportion of females among fawns as the number of females per male among adults in the harvest that will maintain a stable population should enable the wildlife manager to understand the mathematics involved. Once this is understood, he will have a simple but logical tool for deriving quotas for harvesting antlerless deer, the use of which will largely eliminate the need for elaborate population modeling. The primary requisite is a consistent measure of the legal harvest of adult males. Ideally, hunting pressure and hunter success should be similar from year to year so that the buck take truly reflects the population of adult males. Adjustments must be made for differences between the real sex ratios and those that are assumed as well as for any disproportionate removal of adult females by causes other than legal hunting. A

higher proportion of females among the fawns would require a higher ratio of adult females per adult male in the harvest to maintain a stable population. An increase in any disproportionate loss of adult females from causes other than legal hunting would require a lower harvest ratio of adult females.

In practice, the derivation of quotas for harvesting antlerless deer is essentially simple. The number of adult males legally taken in the last season is multiplied by the ratio of females per male that should produce the desired result. It must be emphasized that the correct ratio to apply can only be determined by trying different ratios for a particular management unit and analyzing the effects that these have on subsequent harvests of adult males. Results will vary from unit to unit due to differential unaccounted-for losses to the adult female segment of the population. It is virtually impossible for a ratio to work in the field exactly as it does on paper. Usually a lower ratio will have to be used. Often it will be zero. In any case, success in the use of this method depends on careful attention to population changes.

Most deer managers are confronted with vast areas of land, and detailed studies of extensive deer populations are not feasible. Also, the animals are free to come and go and are influenced by a multitude of variables. A simple, easily applied means of determining proper harvest quotas is needed. Experience in New York, as well as in New Jersey (Burke et al., 1977), has shown that the method described here is sufficiently precise and practical for that purpose.

LITERATURE CITED

BURKE, DAVID, ROBERT E. ERIKSEN, PATRICIA A. MCCONNELL AND ROBERT P. WINKEL. 1977. Deer harvest strategies in New Jersey. Trans. Joint Meeting of Northeast-Southeast Deer Study Group (September 6-8).

CHEATUM, E. L., AND C. W. SEVERINGHAUS. 1950. Variations in fertility of white-tailed deer related to range conditions. Trans. N. Am. Wildl. Conf. 15:170-190.

HESSELTON, W. T., AND L. W. JACKSON. 1974. Reproductive rates of white-tailed deer in New York State. N.Y. Fish and Game Jour. 21(2):135-152.

MAGUIRE, H. F., AND C. W. SEVERINGHAUS. 1954. Wariness as an influence on age composition of white-tailed deer killed by hunters. N.Y. Fish and Game Jour. 1(1):98-109.

SEVERINGHAUS, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Jour. Wildl. Mgt. 13(2):195-216.

SEVERINGHAUS, C. W., AND H. F. MAGUIRE. 1955. Use of age composition data for determining sex ratios among adult deer. N.Y. Fish and Game Jour. 2(2):242-246.

DETERMINING THE AGE OF FISHER FROM CEMENTUM ANNULI OF THE TEETH[1]

Marjorie A. Strickland — Project Biologist (Algonquin Region), Ontario Ministry of Natural Resources,

Carman W. Douglas — Regional Biologist (Algonquin Region), Ontario Ministry of Natural Resources,

Mark K. Brown — Conservation Biologist, New York State Department of Environmental Conservation, Warrensburg, N.Y. 12885

Gary R. Parsons — Associate Wildlife Biologist, New York State Department of Environmental Conservation, Delmar, N.Y. 12054

ABSTRACT

Stained sections of teeth, chiefly premolars, from known-age fisher, representing various time intervals from 7 to 53 months, showed that the first cementum annulus was discernible at about 15 months. After that, the number of annuli corresponded exactly with the age of the animal in years from July through March. Since sex can be determined from the lower canine teeth, data on the sex and age composition of a fisher population can be obtained by collecting only the lower jaw from animals taken during the trapping season.

To understand the population dynamics of a wildlife species, an accurate method of determining age is needed. Such a technique has been lacking for the fisher *(Martes pennanti)*. Age determination for this species has been limited to separation of juveniles from adults by cranial characteristics, fusion of sutures and epipheses, baculum weights and the reproductive state of females (Coulter, 1966; Wright and Coulter, 1967; deVos, 1952; Eadie and Hamilton, 1958; Boise, 1975; Dagg et al., 1975).

Although age determination by counts of annual increments of cementum on the teeth has been used for many species (Klevezal and Kleinenburg, 1967; Sauer et al., 1966; Linhart and Knowlton, 1967; Grace et al., 1970; Monson et al., 1973; Crowe, 1972; Crowe and Strickland, 1975), the applicability of the method to fisher had not been proven. Kelly (1977) used cementum annuli to age fisher but had no known-age animals. He related the number of annuli to the reproductive state of the female and other morphological information.

In the present study data were obtained for eight known-age fisher (two males and six females). Six were born and reared in captivity, and the other two (both females) were obtained as young kits so that their age

---

[1] The authors wish to thank Robert Fuller, Dr. Fred Gilbert, Dr. Roger Powell, Bruce Stephenson and Frank Webb for donating fisher skulls, teeth or animals of known age. The work was partially funded under New York Federal Aid in Fish and Wildlife Restoration Project W-135-R.

could be closely approximated. All were maintained, as much as possible, under natural conditions of light and temperature and were fed dog food, deer meat and beaver meat. The specimens received as kits died when approximately 7 and 13 months old, while of the others one (a male raised by Dr. R. Powell) died at 15½ months and two at about 4½ years.

Teeth from these animals, representing successive years of age (through 4½ years) were extracted for examination. In most cases extraction was performed on the live animal so that some individuals provided data for more than one age. The premolar was selected as the primary tooth for study. However, a canine was used for the kit that died at 7 months, and at the time the two oldest adults died all their teeth were extracted after the skull had been boiled in water for about 3 hours. Live fisher were anesthetized with ketamine (10 milligrams per kilogram) and acepromazine (0.5 milligram per kilogram), and a dental elevator was used to gently work loose the premolar.

Sections from the root part of the tooth, for examination under a microscope, were prepared by two methods.

1. Teeth were decalcified in 5 per cent nitric acid for 3 to 30 hours, depending on their size, and then washed in water, dehydrated and embedded in paraffin. Premolars were embedded whole, while canines were first bissected saggitally. Microtome sections were cut at 10 microns, stained with Harris hematoxylin (8 to 15 minutes) and 0.5 per cent eosin Y (2 minutes).
2. Teeth were decalcified in 20 per cent formic acid and sectioned on a freezing microtome at 12 microns. The sections were stained with Giemsa stain as described by Stone et al. (1975).

Both methods gave good results, and a limited amount of boiling did not affect the sections obtained. In each case, the sections were examined with transmitted light at 40X and 100X.

Examination of the sections revealed layers in the cementum; first a light-stained band adjacent to the dentine-cementum interface; followed, in adults, by alternate dark-stained lines and light-stained bands (Figure 1). The number of dark-stained lines (i.e., annuli) corresponded exactly to the age of the animal in years during the period of July through March (Table 1). In the two instances where all the teeth of the animal were examined, the number of annuli was the same throughout.

The annuli were usually more distinct in the premolars than the canines. Considering all the specimens, including those where all the teeth were extracted, the annuli were clearest at the apices of the roots of the first and second premolars and in the arch between the two roots of the second premolar. For the canines, the annuli were most distinct along the sides of the root but often faded out or split toward the apex. The dentine generally did not show any annulation.

Tooth sections from the eight known-age fisher gave 14 age determina-

Figure 1. Transverse section of premolar tooth extracted in November from known-age fisher 4½ years old, showing dark-stained lines representing cementum annuli.

tions ranging from 7 to 53 months. Based on a birth date of April 1 (Hall, 1942)[2], the number of annuli corresponded exactly to the age in years of the animal during the months of July through March. The annulus, which apparently is formed during the winter, becomes visible about the middle of June when there has been sufficient formation of summer cementum to separate it from the periodontal-cementum interface. Kelly (1977) found that sections from two fisher, captured May 1 and May 22, had a dark-stained area near the periodontal interface that he believed was an annulus being formed. In the present study, the current annulus was not yet obvious in the premolar extracted on May 9 from an animal 1 year and 1 month old. However, the annulus was distinctly separate from the interface in the premolars extracted on June 16 from two fisher that were then 1 year and 3½ months old. Therefore, these data indicate that between the date of birth and at least early June the number of annuli are one less than the age of the animal in years, while during the rest of the year there is exact correspondence.

The pattern of cementum annuli formation in tooth sections from the

[2] Two of the known-age specimens in this study were born in captivity on February 27.

Table 1. Relation of Cementum Annuli to Age For Known-age Fisher Examined

No.*	Sex	Tooth examined	Preparation method§	Date animal born	Date tooth extracted	Known age (years-months)	Number of annuli
A	Female	Canine	1	April 1†	November‡	0 - 7	0
B	Female	pMl	2	April 1†	May 9‡	1 - 1	0
1	Male	pMl	1	February 27, 1979	June 16, 1980	1 - 3 1/2	1
2	Female	pMl	1	February 27, 1979	June 16, 1980	1 - 3 1/2	1
C	Male	pMl	1	March 30, 1974	July 19, 1975	1 - 3 1/2	1
1	Male	pMl	1	February 27, 1979	July 16, 1980	1 - 4 1/2	1
2	Female	pMl	1	February 27, 1979	July 16, 1980	1 - 4 1/2	1
92	Female	pMl	2	April 15, 1974	November 30, 1976	2 - 7 1/2	2
93	Female	pMl	2	April 15, 1974	November 30, 1976	2 - 7 1/2	2
50	Female	pMl	2	April 15, 1974	December 28, 1977	3 - 8 1/2	3
92	Female	pMl	2	April 15, 1974	December 28, 1977	3 - 8 1/2	3
93	Female	pMl	2	April 15, 1974	December 28, 1977	3 - 8 1/2	3
92	Female	All	2	April 15, 1974	August 23, 1978‡	4 - 4 1/2	4
50	Female	All	1	April 15, 1974	September 7, 1978‡	4 - 5	4

* Numerals are specimen identification numbers; letters represent: A - kit collected by Stephenson; B - kit collected by Webb; C - animal raised by Powell.

§ See text.

† Assumed date, animals received as kits.

‡ Animal died.

known-age fisher was compared with that for over 3,000 fall-trapped fisher from Ontario and northern New York. There was a strong similarity between the two groups. However, some 10 per cent of the wild material could not be used because of broken teeth and other abnormalities. Although the age criteria were not confirmed beyond 4½ years, they apparently were consistent through at least 14 years in wild specimens.

As the trapping season for fisher in New York and Ontario usually is between late October and late February, the number of annuli in teeth of animals taken at that time equals their age. If the date of capture is known, and assuming a birth date of April 1, age can be assigned to the nearest month. Since sex can be determined from the lower canine teeth (Parsons et al., 1978) data on the sex and age composition of a fisher population can be obtained by collecting only the lower jaw from animals taken during the trapping season.

LITERATURE CITED

Boise, C. M. 1975. Skull measurements as criteria for aging fisher. N.Y. Fish and Game Jour. 22(1):32.37.

Coulter, M. W. 1966. Ecology and management of fisher in Maine. Ph.D. thesis, Library, State Univ. College of Forestry at Syracuse, N.Y.

Crowe, D. M. 1972. The presence of annuli in bobcat tooth cementum layers. Jour. Wildl. Mgt. 36(4):1330-1332.

Crowe, D. M., and M. D. Strickland. 1975. Dental annulation in the American badger. Jour. Mammal. 56(1):269-272.

Dagg, A. I., D. Leach and G. Sumner-Smith. 1975. Fusion of the distal femoral epiphysis in male and female marten and fisher. Can. Jour. Zool. 53(11):1514-1518.

deVos, A. 1952. Ecology and management of fisher and marten in Ontario. Ont. Dept. Lands and Forests, Tech. Bull., Wildl. Ser. 1.

Eadie, W. R., and W. J. Hamilton. 1958. Reproduction in the fisher in New York. N.Y. Fish and Game Jour. 5(1):77-83.

Grace, G. A., G. C. Sanderson and J. P. Rogers. 1970. Age determination of raccoons. Jour. Wildl. Mgt. 34(2):364-372.

Hall, E. R. 1942. Gestation period in the fisher with recommendations for the animal's protection in California. Calif. Fish and Game 28:143-147.

Kelly, G. M. 1977. Fisher *(Martes pennanti)* biology in the White Mountain National Forest and adjacent areas. Ph.D. thesis, Univ. Mass. Library.

Klevezal, G. A., and S. E. Kleinenberg. 1967. Age determination of mammals from annual layers in teeth and bones. (Transl. from Russian) Isreal Program for Sci. Translations, Jerusalem, T.T. 69-55033.

Linhart, S. B., and F. F. Knowlton. 1967. Determining age of coyotes by tooth cementum layers. Jour. Wildl. Mgt. 31(2):362-365.

Monson, R. A., W. B. Stone and E. Parks. 1973. Aging red foxes *(Vulpes fulva)* by counting the annular cementum rings of their teeth. N.Y. Fish and Game Jour. 20(1):54-61.

Parsons, G. R., M. K. Brown and G. B. Will. 1978. Determining the sex of fisher from the lower canine teeth. N.Y. Fish and Game Jour. 25(1):42-44.

Sauer, P. R., S. Free and S. Browne. 1966. Age determination in black bears from canine tooth sections. N.Y. Fish and Game Jour. 13(2):126-139.

Stone, W. B., A. S. Clausen, D. E. Slingerlands and B. L. Weber. 1975. Use of Romanowsky stains to prepare tooth sections for aging mammals. N.Y. Fish and Game Jour. 22(2):156-158.

Wright, P. L., and M. W. Coulter. 1967. Reproduction and growth in Maine fishers. Jour. Wildl. Mgt. 31(1):70-86.

GENERAL NOTES

AMERICAN BRANT KILLED ON GOLF COURSES BY DIAZINON[1]

Ward B. Stone Associate Wildlife Pathologist
New York State Department of Environmental Conservation, Wildlife Research Center, Delmar, N.Y. 12054

Harry Knoch Senior Wildlife Biologist
New York State Department of Environmental Conservation, Stony Brook, N.Y. 11794

Diazinon (O, O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidyl) phosphorothioate) is a cholinesterase inhibitor insecticide that was introduced in 1952 (Rudd and Genelly, 1956). When used to control insect pests of turf, it has accidentally poisoned birds, such as mallard ducks *(Anas platyrhynchos)*, black ducks *(Anas rubripes)* and Canada geese *(Branta canadensis)*, that fed on grain or grass in areas where it had been applied (Zinkl et al., 1978; Stone, 1979). This paper reports on two cases in New York where it is believed that American brant *(Branta bernicla)* were killed by feeding on golf courses that had been treated with Diazinon. Contact with pesticides applied to turf may be increasing for brant since they appear to be feeding more frequently than in the past on golf courses and other intensively managed grassy areas on Long Island.

Case 1. Brant Killed at Bay Park County Golf Course in Nassau County

On Wednesday, April 12, 1979, Diazinon 14G (granular; 14.3 per cent Diazinon) was applied to the tees and greens of this golf course by a man walking with a cyclone spreader. Rain was forecast, and golf course personnel thought the Diazinon would be rapidly carried into the soil. They apparently did not immediately wash the granules into the soil with water which is the general recommendation of the manufacturer. It didn't rain heavily until April 14, and it rained only intermittently on April 15. On Monday morning, April 16, some 50 to 60 dead American brant were found in a small area of the golf course adjacent to several puddles of accumulated rainwater. Great black-backed gulls *(Larus marinus)* and herring gulls *(Larus argentatus)* were seen feeding on brant carcasses, but no sick or dead gulls were observed. Five brant carcasses picked up on April 16, together with a sample of water taken on April 17 from a puddle with a slight oily film near where the dead brant had been found, were submitted to the Wildlife Pathology Unit for examination.

At necropsy on April 18, the birds were found to be in good flesh although the lungs were congested, but no evidence of salmonellosis, fowl cholera, duck viral enteritis or other infectious or parasitic disease was found. The esophagi and proventriculi contained a few blades of grass, the eyes were sunken and the carcasses were decaying.

The water sample and pools of liver tissue, small intestine with contents and gizzard contents were submitted to the Department's Hale Creek Field Station for gas chromatographic analyses for organophosphate pesticides. The water sample contained 0.70 ppb of Diazinon, while on a wet-weight basis the liver tissue contained 3.0 ppb, the small intestines 2.0 ppb and the gizzard contents 0.77 ppm. Low levels of Diazinon are expected from carcasses that have undergone decay. However, based on the history, field observations, necropsy results and chemical analyses, it was concluded that Diazinon was the highly probable cause of death for these brant.

Case 2. Brant Killed at Merrick Bay Golf Course in Nassau County

Between 8:00 and 9:00 a.m. on May 8, 1980, a greens keeper reportedly applied Diazinon on three fairways of this municipally owned golf course. Golf course personnel indicated they used a 25 per cent emulsible liquid Diazinon mixed at a rate of 6 ounces to 3-5 gallons of water. Approximately 3 to 5 gallons of this material was applied to each 1,000 square feet of grass via a Bean sprayer, with two nozzles, mounted on the back of a pickup truck. It rained following the application of the insecticide. At 1:00 p.m. (about 4 hours after the Diazinon application) golf course personnel found dead brant, and others were seen exhibiting severe

[1] The authors acknowledge the assistance of Samuel Jackling, associate analytical chemist of the N.Y.S. Department of Environmental Conservation.

tremors. About 15 dead brant were picked up shortly thereafter by Town of Hempstead workers.

On the morning of May 9, a Department biologist collected 16 dead brant from the golf course and took a water sample from a nearby puddle (about 3.5 meters in diameter and 10 centimeters deep). Healthy appearing Canada geese (with goslings) were observed on another part of the property. Apparently, in this case, the geese either had not fed at all on the Diazinon-contaminated areas or had not fed there sufficiently to show signs of acute poisoning. However, the brant had been observed grazing on the treated parts of the fairways and drinking from the rain-formed pools there. The dead brant were refrigerated and transported on ice to the Wildlife Pathology Unit on May 11.

At necropsy, the birds were found to be in excellent flesh with abundant subcutaneous and thoraco-abdominal fat supplies. The gross necropsy findings were similar to those in Case 1, except that the carcasses were considerably less decayed. Pooled samples (from four brant) of short grass blades from the esophagi, as well as pooled samples of the gizzards, the liquid contents of the small intestines, and the livers, plus the water sample, were sent to Raltech Scientific Services for gas chromatograph analyses for organophosphate pesticides. In addition, a liquid nitrogen frozen pool of brain tissue from these brant was submitted for determination of the cholinesterase level. The gas chromatograph analyses showed (wet weight) 5.0 ppm of Diazinon in the grass blades, 0.12 ppm in the gizzards, 3.2 ppm in the small intestine contents and a less-than-detectable amount (i.e., less than 0.01 ppm) in the liver. The water sample contained 4.3 ppm of Diazinon. The cholinesterase level in the brain tissue, as wet weight determined according to the method described by Ellman et al. (1961), was 8.1 mU per milligram. No brant were killed as controls, and no value for a normal cholinesterase level for this species was found in the literature. Based on the history, field observations, signs exhibited by the poisoned brant, gross pathology and chemical analyses, it was concluded that the mortality was caused by Diazinon.

DISCUSSION

The brant in these cases appear to have received Diazinon from the grass they ate, the water they consumed from small pools of rainwater and, perhaps, through the integument of their feet as they walked on treated areas of the golf course. The LD_{50} of Diazinon for brant is unknown, but that for mallard ducks (males 3 to 4 months old) averages 3.54 milligrams per kilogram according to Tucker and Crabtree (1970). The LD_{50} in 5-day diets for young mallards is 191 ppm in fresh feed (Hill et al., 1975).

It is possible (especially in Case 2) that drinking the Diazinon-contaminated runoff water contributed substantially to the intoxications. The concentrations of the pesticide in the water may have been higher before they were diluted by continued rain or metabolized. It is certain that grass-grazing birds (e.g., Canada geese and American brant) will continue to be killed by cholinesterase inhibitor insecticides until less toxic compounds and/or different methods of application are developed. The death of large waterfowl is obvious on golf courses, but research is needed on the more subtle toxicities that may be occurring in the fauna (including man) that use turf heavily treated with pesticides.

LITERATURE CITED

Ellman, G. L., K. D. Courtney, V. Andres and R. M. Featherstone. 1961. A new and rapid colorimetric determination of acetylcholinesterase activity. Biochem. Pharmacol. 7:88-95.

Hill, E. R., R. G. Heath, J. W. Spann and J. D. Williams. 1975. Lethal dietary toxicities of environmental pollutants to birds. U.S. Fish and Wildl. Serv., Publ. 191.

Rudd, R. L., and R. E. Genelly. 1956. Pesticides: their use and toxicity in relation to wildlife. Calif. Dept. Fish and Game, Game Bull. 7.

Stone, W. B. 1979. Poisoning of wild birds by organophosphate and carbamate pesticides. N.Y. Fish and Game Jour. 26:37-47.

Tucker, R. K., and D. G. Crabtree. 1970. Handbook of toxicity of pesticides to wildlife. U.S. Fish and Wildl. Serv., Publ. 84.

Zinkl, J. G., J. Rathert and R. R. Hudson. 1978. Diazinon poisoning in wild Canada geese. Jour. Wildl. Mgt. 42:406-408.

SEEFORELLEN IN NEW YORK

Martin H. Garrell — Associate Professor
Physics Department, Adelphi University
South Avenue, Garden City, N.Y. 11530

Lawrence E. Strait — Senior Aquatic Biologist
New York State Department of Environmental Conservation, Ray Brook, N.Y. 12977

Seeforellen is the German name for the lacustrine form *(Salmo trutta lacustris)* of the brown trout. According to Bacmeister (1977b) it is distributed throughout the subalpine regions of western Europe and may also be found in Scandinavia, the British Isles, central Europe and the Soviet Union. It is highly regarded by European fishermen (Figure 1) and is readily taken by a variety of angling techniques.

Figure 1. A typical seeforellen (15 kilograms or 33 pounds) taken from the Walchensee in West Germany. (photo by R. Bouterwek)

The most interesting difference between this form and the stream-dwelling form *(S. trutta fario)* of the brown trout (the one that has become widely established in New York) is in the growth pattern as illustrated in Figure 2. In a number of Bavarian, Austrian and Swiss lakes,

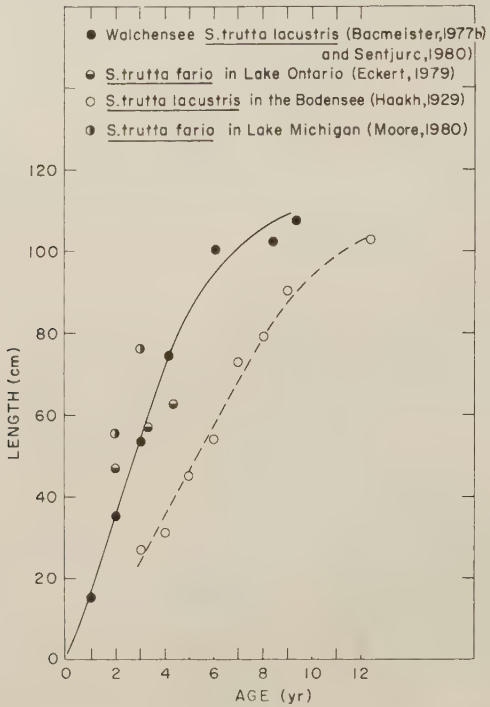


Figure 2. Relative growth rates for seeforellen (*Salmo trutta lacustris*) in two European lakes and for the stream form of the brown trout (*S. trutta fario*) in two North American lakes. Sources of data are indicated in the legend; those for Moore (1980) and Sentjurc (1980) represent personal communications.

TABLE 1. RECORD SEEFORELLEN TAKEN IN EUROPE

Where taken	Year	Weight (kilograms)	How taken	Reference
Germany	1934	31.00	Handline	Tircher (1977)
Germany	1976	27.50	Net	Bacmeister (1977a)
Austria	1974	20.85	Rod and reel	Bacmeister (1977a)
Germany	1972	18.20	Rod and reel	Colas (1972)

seeforellen weighing 20 kilograms (44 pounds) or more have been recorded, and the growth curves given by Haakh (1929) indicate that growth continues most of the adult life of the fish, a span of 12 years or more. Four of the largest specimens on record from Germany and Austria are listed in Table 1. The lake form matures at about age 4, whereas the stream form usually matures at 2 to 3 years of age.

A program to augment the seeforellen population in the Walchensee, a lake in West Germany, was undertaken by the Forellenzucht Grubmuehle, a small hatchery near the lake. The hatchery operation uses eggs and milt from fall spawners as they ascend the tributary streams in October and November. The eggs are then cultured, and the fry and smolts are released into the tributaries.

In August 1978, the State Department of Environmental Conservation accepted an offer from the hatchery manager, Igor Sentjurc, and made arrangements to import 3,000-4,000

seeforellen eggs that would be available in the eyed stage in January 1979. Eggs from a 5-year-old female were fertilized with milt from a 7-year-old male in December 1978, and the eyed eggs, packed in a Styropur carton surrounded by ice, were shipped from Grubmuehle to New York via air cargo on January 10, 1979. To satisfy requirements of the U.S. Fish and Wildlife Service, the eggs were certified to be free of the protozoan, *Myxosoma cerebralis*, and viral hemorrhaegic septicemia. The eggs were also certified to be free of infectious haematopoietic necrosis and infectious pancreatic necrosis; both these diseases were described by Roberts and Shepherd (1974). They were inspected at Kennedy Airport by U.S. Fish and Wildlife Service and Customs officials and then transported to the State fish hatchery at Rome via hatchery truck. Within 36 hours after their departure from Bavaria, the eggs were immersed in a temperature bath and brought up to 4° C.

Of the 3,886 eyed eggs received, most hatched on or before January 18, 1979. Over-all mortality by October 1, 1979, including those lost as a result of a frog-plugged drain, was about 18 per cent, indicating a reasonable survival for wild fish (Figure 3). The fry were fed Rangen

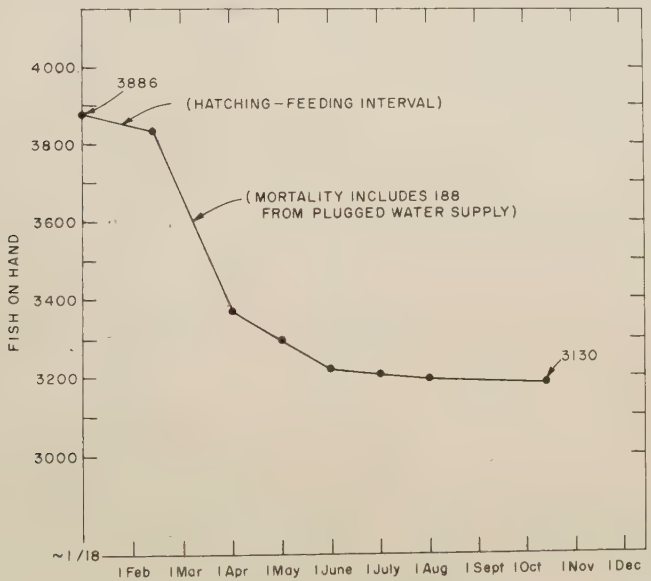


Figure 3. Survival of seeforellen fry at the Rome (N.Y.) hatchery from January 18 to October 12 in 1979.

feed and, although slow growing and skittish, they took food well. The fish numbered 340 per kilogram by October 1, and 2,990 totalling 11 kilograms were stocked on October 12 in Mountain Pond, a 22-hectare (55-acre) pond in Franklin County near Paul Smiths. This pond had also been stocked with Temiscamie strain brook trout *(Salvelinus fontinalis)* and, while fishing was permitted, no trout might be killed.

The remaining seeforellen (200) were kept at the Rome hatchery and placed in first-use water. On December 20, 1979, after losses due to furunculosis (possibly the result of fin-clipping stress), 146 fish, representing 140 per kilogram, remained. By May 2, 1980 there were 140 survivors (41.8 per kilogram) and by April 16, 1981 the number was 103 (11.9 per kilogram) that averaged 19.5 centimeters long. Sizes at the hatchery corresponded to those observed in Bavaria. The fish exhibited the normal coloration of juvenile seeforellen, i.e., white from the ventral surface toward the lateral line and a silvery body.

During the fall of 1980, 89 having a mean length of 24.6 centimeters were moved from Mountain Pond to nearby Boy Scout Clear, a 33-hectare (83-acre) pond on property owned by the Boy Scouts of America. According to current (1981) regulations, the scouts who fish there may keep brook trout but must release all other salmonids. The seeforellen were fin clipped for identification. Recent observations in these ponds have demonstrated that juvenile seeforellen can be taken by angling.

It is hoped that fertilized eggs will be obtained from the Mountain Pond fish and/or the hatchery stock when they reach maturity in about four years. A possible outcome might be a program for stocking large bodies of water having highly oxygenated hypolimnions and ample forage, such as Lake Ontario, Lake Champlain, the Finger Lakes and certain New York City reservoirs, to provide trophy-fish angling. If such stocking becomes possible, it may be difficult to maintain the pure, faster-growing seeforelle strain against hybridization with the presently-existing stream form. Hybrids appear to be slower growing according to records of the Grubmuehle hatchery. There may also be law enforcement problems due to the slow maturation of seeforelle; typical mature 4 year olds measure about 60 centimeters long. Finally, large, long-lived specimens may accumulate high levels of pesticides and other contaminants in certain waters. Nevertheless, the seeforellen offers promise as a means of providing additional sport fishing in waters to which it is adapted.

LITERATURE CITED

Bacmeister, Arnold. 1977a. Traumgrenzen. Blinker 1977(2):28-32.

_____ 1977b. Seeforelle. Blinker 1977(6):113.

Colas, Hans. 1972. Seeforellen Triumphe. Fisch und Fang 13(5):268-272.

Eckhart, Thomas H. 1979. Brown trout assessment in Lake Ontario. Great Lakes Fishery Comm. Lake Ontario meeting. N.Y.S. Dept. Environ. Cons Rept. (mimeo.)

Haakh, Theodor. 1929. Studien ueber Alter und Wachstum der Bodensee-fische. Archiv fuer Hydrobiologie 20(2):214-295.

Roberts, Ronald J., and C. J. Shepherd. 1974. Handbook of Trout and Salmon Diseases. Fishing News (Books) LtD., Surrey, England.

Tircher, Serge. 1977. Die Schwersten Seeforellen unseres Jahrhunderts. Blinker 1977 (4):82-83.

COMPARISON OF FRESH WEIGHT AND OVEN-DRIED WEIGHT OF WHITE CEDAR BROWSE

C. W. Severinghaus Severinghaus Wildlife Consultants
J.D. Severinghaus Voorheesville, N.Y. 12186

The water content of vegetation varies considerably. Davenport (1939) reported losses of 41 to 53 per cent between fresh weight and oven-dried weight for various sorts of deer forage. Oven-dried weight was used by Severinghaus and Severinghaus (1982) to assess forage production of white cedar *(Thuja occidentalis)* in wire-protected deer feeders on an area in Schoharie County (N.Y.).

The fresh browse was clipped during September, October and November. All clippings were placed in brown grocery bags, and the fresh weight (minus the bag weight) was recorded in grams. The early samples were air dried for about 3 months in a secondfloor barn loft. Then they were oven dried. Later samples were oven dried without being air dried.

All the clipped browse was oven dried at 50° C. for 48 hours. A few samples lost more than 1 per cent of their fresh weight during the last 8 hours of oven drying. These were dried for an additional 8 to 12 hours or until their weight loss was less than 1 per cent in an 8-hour period. Why some samples dried more slowly than others was unknown.

The air-dried samples weighed 4,063.5 grams, and after being oven dried they weighed 3,795.9 grams, i.e., 93.41 per cent of the air-dried weight. Three samples provided a comparison between fresh weight and oven-dried weight (Table 1). Weights of the browse after

Table 1. Difference Between Fresh Weight and Oven-dried Weight of White Cedar Browse

Sample	Year clipped	Fresh weight (grams)	Oven-dried weight	
			Grams	Percentage of fresh weight
1	1978	3,322.89	1,743.09	52.46
2	1979	5,219.67	2,231.67	42.76
3	1979	7,364.95	3,497.95	47.49

being oven dried ranged from 52.46 to 42.76 per cent of the fresh weight. There were no observations that would explain this wide difference. The samples were clipped during dry weather, daytime temperatures were in the 70's (Fahrenheit), and all clippings in the grocery bags were carried in a plastic bag and weighed at the end of each day. The first sample (which had the least weight loss) was clipped in 1978, and the other two were clipped in 1979. Because of the wide variation in water content, as illustrated by these data, oven-dried weight is preferable to fresh weight for measuring forage consumption.

LITERATURE CITED

Davenport, L. A. 1939. Results of deer feeding experiments at Cusino, Michigan. Trans. N. Am. Wildl. Conf. 4:268-274.

Severinghaus, C. W., and J. D. Severinghaus. 1982. Providing white cedar as winter browse for deer without incurring overbrowsing. N.Y. Fish and Game Jour. 29(1):45-64.

SARCOPTIC MANGE IN A GRAY FOX

Ward B. Stone — Associate Wildlife Pathologist
New York State Department of Environmental Conservation, Wildlife Resources Center, Delmar, N.Y. 12054

Ira F. Salkin — Research Scientist IV
New York State Department of Health, Division of Laboratories and Research, Albany, N.Y. 12201

Alan Martel — Senior Fish and Wildlife Technician
New York State Department of Environmental Conservation, Stamford, N.Y. 12167

Sarcoptic mange was reported (Pryor, 1956) in two of 55,706 gray foxes *(Urocyon cinereoargenteus)* pelts from Pennsylvania, but no attempt was made to confirm the infestations by microscopic examination. Neither Trainer and Hale (1969) in Wisconsin nor Stone et al. (1974) in New York found sarcoptic mange in gray foxes, even though the disease is common in red foxes *(Vulpes fulva)* in both states. Experimental infestations of captive gray foxes with *Sarcoptes scabiei* mites of red fox origin resulted in only a mild, transitory disease (Stone et al., 1972). This note describes the first microscopically confirmed case of sarcoptic mange in a free-living gray fox.

A gray fox, that appeared to be sick, was shot during daylight on November 14, 1979 in the Town of Stamford in Delaware County (N.Y.) and submitted to the Wildlife Pathology Unit at Delmar for examination. The fox was found at necropsy to be a severely debiliated male with a gross weight of 4,127 grams. Microscopic examination of tooth sections (Stone et al., 1975) showed it to be about 1½ years old. While partially alopecic areas with weeping, encrusted lesions were present on the front and hind legs, abdomen, tail, ears and snout, the most severe lesions were on the lateral aspects of the hocks and elbows. The axillary and inguinal lymph nodes and spleen appeared greatly enlarged. Although the animal seemed in good flesh there were no subcutaneous, pericardial, perirenal or abdominal fat deposits. The stomach contained corn and squash indicating apparent feeding on post-harvest garden vegetables. Multiple birdshot wounds were the immediate cause of death.

Studies of lactophenol-cleared skin scrapings taken from the hocks, tail and snout showed numerous *S. scabiei* mites, together with many mite eggs and large quantities of mite feces. Identification was made according to the criteria described by Fain (1968) and Pence et al. (1975). Microscopic examination of Giemsa-stained smears of skin scrapings revealed numerous bottle-shaped, budding yeastlike organisms morphologically consistent with *Malassezia (Pityrosporum) pachydermatis.* Nutrient media inoculated with skin samples by the Laboratories for Mycobacteriology of the State Department of Health yielded *M. pachydermatis.* While this yeastlike pathogen has been found associated with sarcoptic mange in the red fox, porcupine *(Erethizon dorsatum)* and coyote *(Canis latrans)* in New York State (Salkin et al., 1980), this is the first report of its presence in a gray fox.

While more than 400 gray foxes have been submitted to the Wildlife Pathology Unit for diagnosis in the last 10 years, this is the first gray fox to have sarcoptic mange. The disease adversely affected the host's health and probably would have killed the animal. If a strain of *S. scabiei,* adapted and highly pathogenic to the gray fox, were to become established it could become an important population-limiting factor. However, it is possible that this case represents merely an individual more susceptible to mange infestation than the majority of gray foxes. What role, if any, *M. pachydermatis* plays with respect to sarcoptic mange remains unclear.

LITERATURE CITED

Fain, A. 1968. Etude de la variabilite de Sarcoptes scabiei avac une revision des Sarcoptidae. Acta Zool. Path. Antverp 47:1-196.

Pence, D. B., S. D. Casto and W. M. Samuel. 1975. Variation in the chaetotaxy and denticulation of *Sarcoptes scabiei* (Acarina: Sarcoptidae) from wild canids. Acarologia 15:160-165.

Pryor, L. B. 1956. Sarcoptic mange in wild foxes in Pennsylvania. Jour. Mammal. 37:90-93.

Salkin, I. F., W. B. Stone and M. A. Gordon. 1980. Association of *Malassezia (Pityrosporum) pachydematis* with sarcoptic mange in New York State. Jour. Wildl. Disease 16:509-514.

Stone, W. B., E. Parks, B. L. Weber and F. J. Parks. 1972. Experimental transfer of sarcoptic mange from red foxes and wild canids to captive wildlife and domestic animals. N.Y. Fish and Game Jour. 19:1-11.

Stone, W. B., B. F. Tullar, J. B. Zeh and B. L. Weber. 1974. Incidence and distribution of mange mites in foxes in New York. N.Y. Fish and Game Jour. 21:163-166.

Stone, W. B., A. S. Clauson, D. E. Slingerlands and B. L. Weber. 1975. Use of Romanowsky stains to prepare tooth sections for aging mammals. N.Y. Fish and Game Jour. 22:156-158.

Trainer, D. O., and J. B. Hale. 1969. Sarcoptic mange in red foxes and coyotes of Wisconsin. Bull. Wildl. Disease Assoc. 5:387-391.

GIEMSA-STAINED SECTIONS OF PECTORAL FIN RAYS FOR DETERMINING THE AGE OF STURGEON[1]

Ward B. Stone — Associate Wildlife Pathologist
New York State Department of Environmental Conservation, Wildlife Resources Center, Delmar, N.Y. 12054

Anne M. Narahara — Biologist (Volunteer)
New York State Department of Environmental Conservation, Wildlife Resources Center, Delmar, N.Y. 12054

William L. Dovel — Fisheries Biologist
Oceanic Society, Stamford, Conn. 06902

Determining the age of sturgeon *(Acipenser* sp.*)* is usually done by microscopically examining transverse sections of the pectoral fin rays for annuli. Cuerrier and Roussow (1951), using a jeweler's saw, cut a 0.3 to 0.5-millimeter-thick section of bone from near the base of the marginal ray of this fin. The bone slice was mounted on a glass slide in glycerine and observed under a binocular microscope at low magnification. Similar methods have also been used for bone sections mounted in Canada balsam (Sokolov and Akimova, 1976) or examined in methanol (Dadswell, 1979). However, in the authors' experience with these thick, unstained, non-decalcified sections, it is often very difficult to identify the annual increments in the bone. This note describes a method for processing fin rays from shortnose sturgeon *(Acipenser brevirostrum)* using Giemsa-stained sections of decalcified ray cut on a freezing microtome. The procedure is a modification of a technique used for determining the age of mammals from Giemsa-stained tooth sections (Stone et al., 1975).

[1] Funded in part by the Oceanic Society, Stamford, Conn. The authors thank M. Dadswell for the fin samples from sturgeon from the St. Johns River.

Figure 1. Transverse section of marginal ray from the pectoral fin of a shortnose sturgeon showing annuli indicating the fish to have been about 7 years old. The dark-stained zones of bone are formed during periods of rapid growth (e.g., spring and summer) and the light-stained areas are produced during times of slow growth (e.g., winter and the spawning season).

The material used comprised 134 pectoral fin rays from 119 shortnose sturgeon taken from the Hudson River in New York in May-June 1979 and 15 from sturgeon taken in October 1979 and February 1980 from the St. Johns River estuary in New Brunswick (Canada). The fin rays had been air dried for 6 to 18 months. Cross sections of the marginal rays, 3 to 5 millimeters thick, were cut near the base with a jeweler's saw (14 teeth per centimeter). These were decalcified in formic acid in the presence of an ion-exchange resin (Win 3000: Sterling Drug, Inc., New York, N.Y.). Ten grams of the resin (ammonium polystyrene sulfonate) were layered on the bottom of a jar containing 80 milliliters of 20 per cent formic acid. The pieces of ray were placed in individual containers of formic acid on the resin surface and at room temperature (25° to 30° C.) became rubbery in 24 to 48 hours. The decalcified pieces were placed in distilled water for 24 hours and then transversely sectioned on a freezing microtome (− 20° C.) at a thickness of 14 μ. The sections were placed on glass microscope slides and air dried on a slide warmer for 24 hours, following which they were stained with Giemsa stain (Carolina Biological Supply Co., Burlington, North Carolina) diluted one part Giemsa to five parts distilled water for 50 minutes. Fresh dilutions of Giemsa should be made up at least daily, as the diluted stain rapidly loses its staining properties. After staining, the slides were rinsed twice in tap water, once in distilled water and dried for about 24 hours. They were mounted in Euparal (G.B.I. Laboratories LTD., Manchester, U.K.) and read with a compound microscope under a scanning lens (40×).

This method provides permanent slides of a more consistent quality than can be obtained from non-decalcified bone and the thick-slice techniques. Figure 1 shows a typical Giemsa-stained section of ray. The better differentiation of the zones of the bone and the relative simplicity of the technique should make this method useful for those studying sturgeon.

Literature Cited

Cuerrier, J. P., and G. Roussow. 1951. Age and growth of lake sturgeon from Lake St. Francis, St. Lawrence River. Report on material collected in 1947. Can. Fish. Cult. 10:17-29.

Dadswell, M. J. 1979. Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* LeSuer 1818 (Osteichthyes: Acipenseridae), in the Saint John River estuary, New Brunswick, Canada. Can. Jour. Zool. 57:2186-2210.

Sokolov, L. I., and N. V. Akimova. 1976. Age determination of the Lena River sturgeon *(Acipener baeri)*. Vopr. ikhtiol. 16:773-778. (in English).

Stone, W. B., A. S. Clauson, D. E. Slingerlands and B. L. Weber. 1975. Use of Romanowsky stains to prepare tooth sections for aging mammals. N.Y. Fish and Game Jour. 22:156-158.

FIRST RECORD OF THE BLUESPOTTED CORNETFISH IN THE HUDSON RIVER[1]

Byron H. Young Senior Aquatic Biologist (Marine)

Ian H. Morrow Seasonal Technician[2]

Scott R. Wanner Seasonal Technician[3]

New York State Department of Environmental Conservation, Stony Brook, N.Y. 11794

The bluespotted cornetfish *(Fistularia tabacaria)* has a range described as tropical, southward to middle Brazil and common in the West Indies. Böhlke and Chaplin (1968) noted that it has been recorded from both sides of the Atlantic; in the western Atlantic from New England and Bermuda to southeastern Brazil, including the Gulf of Mexico. Dahlberg (1975) described its distribution in Georgia waters as primarily offshore but reported from coastal habitat. It rarely wanders north as far as Massachusetts Bay and Nova Scotia (Breder, 1948; Bigelow and Schroeder, 1953). Briggs (unpublished) listed the species as uncommon in New York's coastal waters, although he reported specimens from Staten Island and Long Island Sound as well as the surf and bays on the south shore of Long Island. A literature search revealed no records from the Hudson River.

On September 5, 1980, the authors netted a bluespotted cornetfish from the Hudson River at river mile 26 near Grand-View-On-The-Hudson. It was captured at 11:50 a.m. on an ebbing tide; the water temperature was 26° C. and salinity was approximately 10 ppt. The specimen measured 212 millimeters in total length including the elongated filament of the caudal fin. It is preserved in the Hudson River collection maintained at the New Paltz office of the Department of Environmental Conservation.

Not only is this specimen apparently the first record from the Hudson River, but it is also of interest because of the low salinity where it was taken. Every other capture in New York has been in more saline waters (20 + ppt), except the one at Staten Island (Texas Instruments, 1977) where the salinity was 16.8 ppt.

LITERATURE CITED

Bigelow, Henry B., and William C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish and Wildl. Serv., Fish. Bull. 53(74).

Böhlke, James E., and Charles C. G. Chaplin. 1968. Fishes of the Bahamas and Adjacent Waters. Phila. Acad. Nat. Sci. (Livingston Publ. Co., Wynnewood, Pa.)

Breder, Charles M. Jr. 1948. Field Book of Marine Fishes of the Atlantic Coast. G. P. Putnams Sons, New York.

Dahlberg, Michael D. 1975. Guide to Coastal Fishes of Georgia and Nearby States. Univ. Georgia Press, Athens.

Texas Instruments. 1977. 1974 year = class report for the multi-plant impact study of the Hudson River estuary, Vol. III, lower estuary study. (prepared for Consolidated Edison Co. of New York)

---

[1] Contribution of Division of Marine Resources.

[2] Present address: 22 Tamara Lane, Cornwall, N.Y. 12518.

[3] Present address: Route 233, R.D. #2, Rome, N.Y. 12440

AGE AND GROWTH OF BOWFIN IN BUTTERFIELD LAKE, NEW YORK

Albert Schiavone, Jr. Senior Aquatic Biologist
New York State Department of Environmental Conservation, Watertown, N.Y. 13601

There is little information available on the growth of bowfin *(Amia calva)* in New York waters. Growth data have been published for populations in the Montreal region of Quebec (Cartier and Magnin, 1967) and in a Michigan lake (Cooper and Schafer, 1954).

During July 1978, 24 bowfin were collected with trapnets and gillnets from Butterfield Lake in Jefferson County (N.Y.) At the time of capture, total length measurements and scale samples were taken. Scale impressions were made on cellulose acetate slides and examined

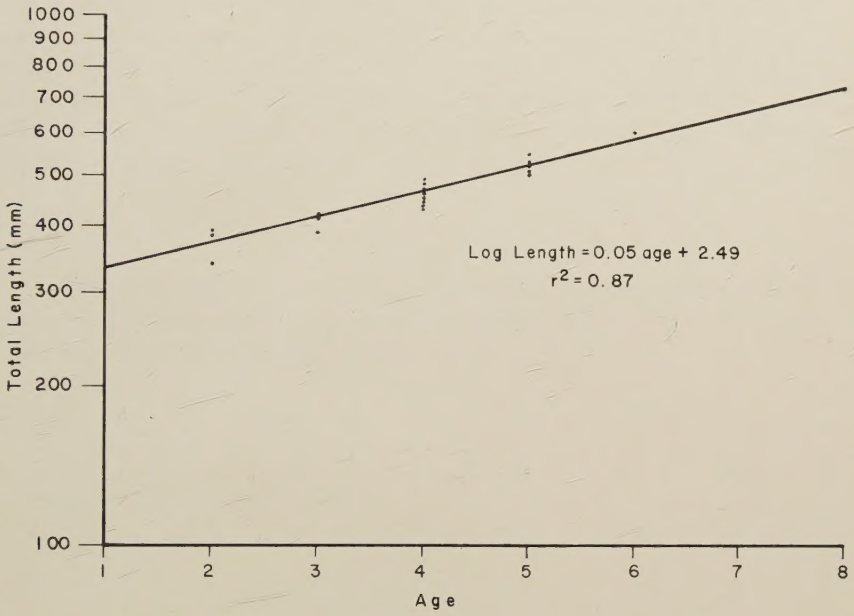


Figure 1. Age-length relationship for 20 bowfin collected in Butterfield Lake in July 1978.

with a binocular microscope to determine age. Age determination from the cycloid scales was difficult, but the findings were in general agreement with those given by Scott and Crossman (1973). The age-length relationship for the 20 specimens aged is shown in Figure 1.

LITERATURE CITED

CARTIER, D., AND E. MAGNIN. 1967. La croissance en longuer et en poids des *Amia calva* L. de la region de Montreal. Can. Jour. Zool. 45(5):797-804.

COOPER, G. P., AND R. N. SCHAFER. 1954. Studies on the population of legal-size fish in Whitmore Lake, Washtenaw and Livingstone Counties, Michigan. Trans. N. Am. Wildl. Conf. 19:239-258.

SCOTT, W. B., AND E. J. CROSSMAN. 1973. Freshwater fishes of Canada. Jour. Fish. Res. Bd. Canada, Bull. 184.

The *New York Fish and Game Journal* is devoted to presenting the results of research and management studies in New York, and other technical papers on related subjects, that pertain to fish and wildlife problems of concern to the Department of Environmental Conservation. It is published semi-annually and is distributed free to official conservation agencies and scientific organizations in New York State. Others may subscribe at a rate of $1.50 per year or obtain individual issues for 75¢ per copy. Correspondence should be addressed to the Editor Robert W. Darrow, New York State Department of Environmental Conservation, Wildlife Resources Center, Delmar, N.Y. 12054.

The contents of this Journal are not copyrighted and may be reproduced elsewhere provided credit is given to the authors and the New York State Department of Environmental Conservation.

FW-P27

CONTENTS

THE ECOLOGICAL ZONES OF NORTHERN NEW YORK . . . *Gary B. Will, Randall D. Strumvoll, Robert F. Gotie and Edward S. Smith* 1

EARLY HISTORY OF THE ATLANTIC SALMON IN NEW YORK *Dwight A. Webster* 26

PROVIDING WHITE CEDAR AS WINTER BROWSE FOR DEER WITHOUT INCURRING OVERBROWSING *C. W. Severinghaus and J. D. Severinghaus* 45

DIET COMPOSITION AND DIEL FEEDING PERIODICITY OF SOME FISHES IN THE ST. LAWRENCE RIVER *Neil H. Ringler and James H. Johnson* 65

BASIS FOR USING SELECTED SEX RATIOS IN THE HARVEST FOR DERIVING QUOTAS FOR HARVESTING ANTLERLESS DEER *Nathaniel R. Dickinson* 75

DETERMINING THE AGE OF FISHER FROM CEMENTUM ANNULI OF THE TEETH *Marjorie A. Strickland, Carman W. Douglas, Mark K. Brown and Gary R. Parsons* 90

GENERAL NOTES 95

AMERICAN BRANT KILLED ON GOLF COURSES BY DIAZINON, *Ward B. Stone and Harry Knoch;* SEEFORELLEN IN NEW YORK, *Martin H. Garrell and Lawrence E. Strait;* COMPARISON OF FRESH WEIGHT AND OVEN-DRIED WEIGHT OF WHITE CEDAR BROWSE, *C. W. Severinghaus and J. D. Severinghaus;* SARCOPTIC MANGE IN A GRAY FOX, *Ward B. Stone, Ira F. Salkin and Alan Martel;* GIEMSA-STAINED SECTIONS OF PECTORAL FIN RAYS FOR DETERMINING THE AGE OF STURGEON, *Ward B. Stone, Anne M. Narahara and William L. Dovel;* FIRST RECORD OF THE BLUESPOTTED CORNETFISH IN THE HUDSON RIVER, *Byron H. Young, Ian H. Morrow and Scott R. Wanner;* AGE AND GROWTH OF BOWFIN IN BUTTERFIELD LAKE, NEW YORK, *Albert Schiavone, Jr.*